METRO TORONTO & REGION REMEDIAL ACTION PLAN

DRY WEATHER DISCHARGES TO THE METROPOLITAN TORONTO WATERFRONT

Remedial Action Plan
Plan d'Assainissement

Canada Ontario

1/5/93

COVER IMAGE SHOWING THE METROPOLITAN TORONTO WATERFRONT:
Scanned from the LANDSAT Thematic Mapper False Colour Infrared Image (1990 09 02),
archive of the Provincial Remote Sensing Office, Ministry of Natural Resources.
Vegetation appears in shades of red. Bare soil and pavement appears in shades of turquoise.

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DRY WEATHER DISCHARGES TO THE METROPOLITAN TORONTO WATERFRONT

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DRY WEATHER DISCHARGES TO THE METROPOLITAN TORONTO WATERFRONT

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The Metropolitan Toronto and Region Remedial Action Plan

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EXECUTIVE SUMMARY

In support of the development of the Metropolitan Toronto and Region Remedial Action Plan this report presents a study summary of direct dry weather discharges to the Metropolitan Toronto Waterfront. The sources addressed in this study consist of dry weather discharges from: sewer outfalls, three water filtration plants (WFPs) and four water pollution control plants (WPCPs).

The study, initiated in 1989, involved the collection of water samples from each source, making flow measurements and then synthesizing the results into statistical summaries of flow, contaminant concentrations and contaminant mass discharges. Each sample was analyzed for a comprehensive list of parameters which included general water chemistry, bacteriology, nutrients, heavy metals and trace organic compounds. A special emphasis was placed on the analysis of PCBs, organochlorine and chlorobenzene pesticides. This involved the collection of large volume samples and the use of special analytical techniques to provide low level detection limit capabilities.

Many of the chemical data sets contained data at or below the analytical detection limit. Non-traditional statistical techniques such as the Maximum Likelihood Estimator were used in the analyses of these data sets.

Summaries of contaminant detection frequencies, mean concentrations and mass loadings by discharge type are included in this report. The mean chemical concentrations for selected parameters are presented graphically by source and discharge type. Similarly, the mean contaminant mass loadings are presented by discharge type. A measure of variability associated with each estimate is represented by a 95% confidence interval, wherever possible. Where applicable, the mean contaminant concentrations are compared to Provincial Water Quality Objectives/Guidelines (PWQO/Gs) and the Metro Toronto Sewer Use Bylaw.

The following summarizes the major statements derived from this study:

Compilation of Contaminant Database

- Low level analytical techniques used in the analysis of trace organic compounds improved the analytical detection limit by a factor of 10 over traditional methods. This has resulted in the identification of more priority pollutants and produced higher detection frequencies than previous studies.

- A list of parameters with relatively high detection frequencies has been compiled. The list includes parameters from the following organic contaminant groupings: chlorobenzenes, organochlorine pesticides, chlorophenol pesticides, volatile organics, resins and fatty acids, and polynuclear aromatic hydrocarbons.

- Parameters where discharge concentrations are generally in exceedance of applicable receiving water criteria have also been identified for consideration in future regulatory monitoring programs.

Contaminant Concentration Characteristics

- Thirty-one of 103 sewer outfalls located along the waterfront have been identified as discharging significant dry weather flow. With the exception of one outfall, each outfall discharge is in exceedance of PWQO/Gs for several parameters.

- Sewer outfall discharge concentrations are lower than PWQO/Gs for trace organic parameters which have PWQO/Gs.

- With the exception of fecal coliform bacteria, sewer outfall discharges are lower in contaminant concentrations than WFPs and WPCPs. In comparison to WPCPs, concentrations in outfalls are similar for suspended solids, aluminum, copper, manganese, zinc, dieldrin and 1,2,3,5 tetrachlorobenzene.

- A ranking of 31 outfall discharges with respect to significance of flow and contaminant concentrations has been included for the prioritization of outfalls requiring remediation.

- WFPs also exceed PWQO/Gs for most conventional parameters and heavy metals. WFP backwash is however, lower than PWQO/Gs for fecal coliforms and trace organic contaminants. Clarifiers which are used to remove the suspended solids from the backwash water at the F.J. Horgan Plant are attributed with reducing contaminant concentrations in the backwash water by approximately one order of magnitude over the other plants which do not provide backwash treatment capabilities.

  In comparison to WPCPs, WFPs discharge higher concentrations of suspended solids, aluminum and iron.

- WPCP effluent concentrations are generally higher than those measured for sewer outfalls and WFPs for most parameters. These concentrations are higher than PWQO/Gs for most conventional parameters and heavy metals. With the exception of lindane, effluent concentrations are lower than PWQO/Gs for trace organic parameters which have PWQO/Gs.

- A full evaluation of the significance of contaminant concentrations measured in this study is not possible because PWQO/Gs have not yet been established for many parameters.

Comparison of Contaminant Mass Discharges

- For the sources considered in this study, WPCPs are generally the most significant source of contaminant mass discharges to the waterfront. In comparison to the sewer outfalls and the WFPs, the WPCP contaminant contribution is typically one to two orders of magnitude larger.

- Waterfront outfalls are the largest source of dry weather fecal coliform loadings, exceeding WPCP loadings by two orders of magnitude. Otherwise, contaminant loadings from all waterfront outfall discharges are lower than WPCP discharges for all parameters. Outfall loadings for parameters such as aluminum, barium, copper, dieldrin, chlorodibromomethane, trichloroethylene, oleic acid, palmitic acid and stearic acid are within an order of magnitude of WPCP loadings.

- WFPs contribute the largest source of aluminum. Aluminum loadings are however, expected to be significant since aluminum is used as a coagulant to remove suspended solids. In comparison to WPCPs, WFPs are significant sources (within an order of magnitude) of total suspended solids, barium, chromium, iron, mercury and volatile organic compounds such as chlorodibromomethane, chloroform and trichloroethylene.

It should be emphasized that while this report presents a comprehensive analysis of direct dry weather discharges to the waterfront, a comparison between all sources discharging to the waterfront requires the completion of separate studies evaluating contaminant discharges from the tributaries discharging to the waterfront and waterfront sewer outfalls during wet weather.

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1.0 INTRODUCTION

1.1 Background

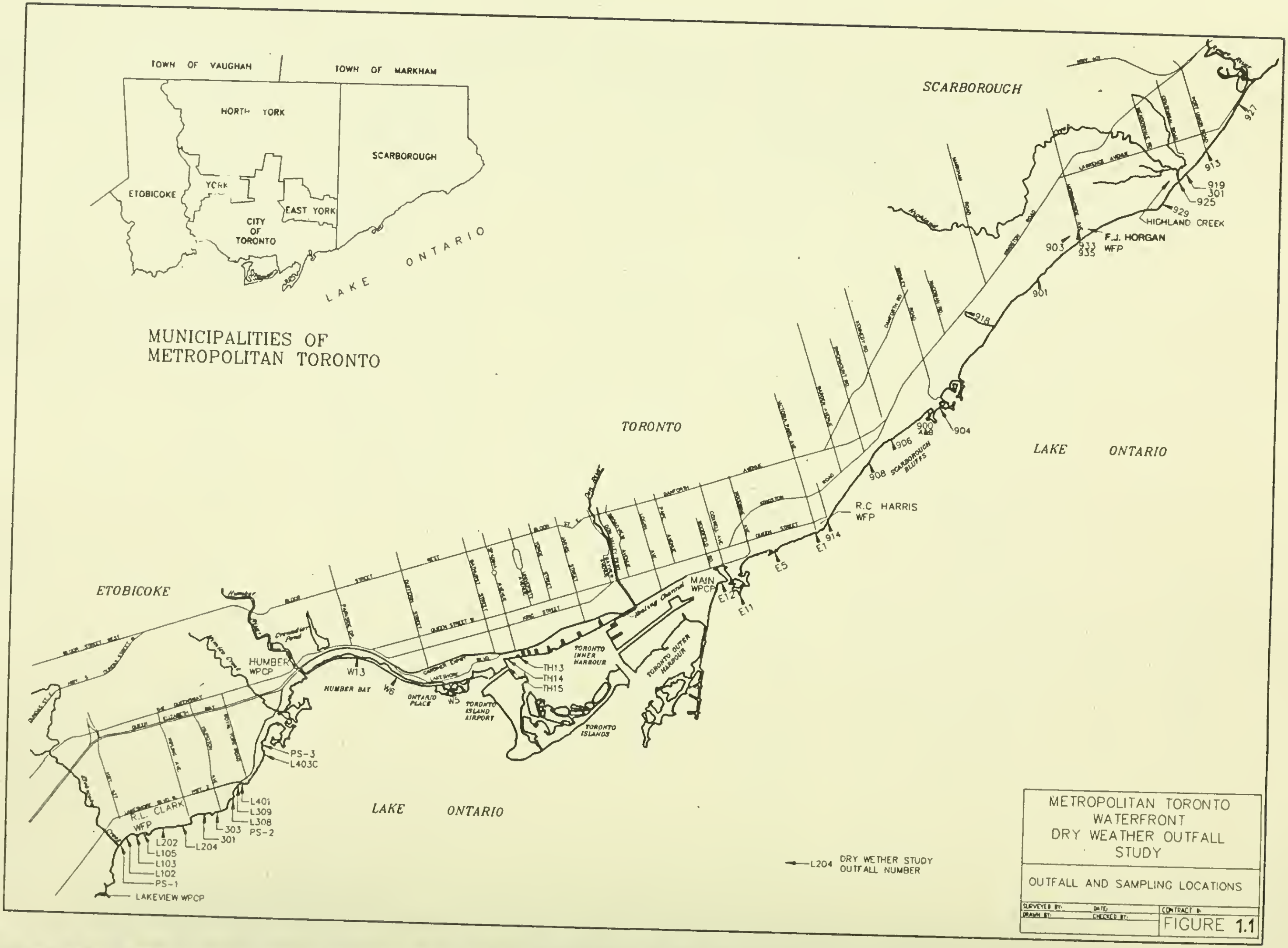
The Metropolitan Toronto Waterfront has been designated as one of 17 areas of concern in Ontario by the International Joint Commission (IJC). The IJC has recommended the development of a Remedial Action Plan (RAP) for the restoration of the waterfront to its desired uses. The RAP is to include a description of the causes of pollution and proposed measures for remediation. In developing the Metropolitan Toronto and Region RAP, the RAP Team has recognized a deficiency in contaminant and flow data for various discharges to the waterfront.

The Metropolitan Toronto Waterfront extending west from Etobicoke Creek and east to the Rouge River receives flow from the following sources:

- effluent from three water pollution control plants (WPCPs),
- backwash water from three water filtration plants (WFPs),
- over 100 storm sewers (31 of which receive combined sewer overflows),
- six watersheds (Humber, Don and Rouge Rivers, and Etobicoke, Mimico and Highland Creeks).

In support of the development of the RAP, a comprehensive study of direct dry weather discharges to the Metropolitan Toronto Waterfront was initiated in 1989. The sources addressed in this study are presented in Figure 1.1 and consist of: dry weather discharges from sewer outfalls, backwash water discharges from the WFPs and the effluent discharges from the WPCPs.

Contaminant discharges from the six watersheds and wet weather discharges from waterfront storm sewer, combined sewer overflows and bypass flows from WPCPs are being addressed in separate studies.



METROPOLITAN TORONTO
WATERFRONT
DRY WEATHER OUTFALL
STUDY

OUTFALL AND SAMPLING LOCATIONS

SURVEYED BY: DATE: CONTRACT №
DRAWN BY: CHECKED BY:

FIGURE 1.1

Under contract to the Ontario Ministry of the Environment (MOE), Beak Consultants Limited and Paul Theil Associates Limited were responsible for the field work and data analysis components of the study. The MOE Laboratory Services Branch performed the chemical analysis for all compounds with the exception of the large volume trace organics analyses. Mann Testing Laboratories, under contract to MOE, performed these analyses.

This report summarizes the results of the report on dry weather discharges to the waterfront submitted to MOE by Beak et al. (1991).

1.2 Receiving Water Impacts Attributed to Direct Waterfront Discharges

The Remedial Action Plan Team (Environment Canada, et al., 1990) has summarized the major environmental impairment of the nearshore areas along the waterfront. Those impairments attributable to the sources considered in this study, include:

- Beach closures as a result of elevated bacterial densities in excess of the Provincial Water Quality Objectives. This is attributed to discharges from storm sewers, combined sewer overflows and bypasses from the water pollution control plants.

- High nutrient levels, particularly phosphorus which results in nuisance algal growth in some sections of the waterfront. The water pollution control plants have been identified as the primary source of phosphorus discharges.

- Degraded water clarity, which is influenced by nutrient controlled algal growth and discharges of suspended solids.

- Elevated levels of nutrients, organics and metals in freshwater sediments. Sediment contamination is principally associated with local sources such as water pollution control plant discharges and sewer discharges.

- A stressed aquatic community, including benthic (sediment dwelling) organisms, primarily in areas close to direct discharges such as water pollution control plants and sewer outfalls.

1.3 Study Objectives

The primary objectives of the study were to determine the following characteristics of direct dry weather discharges to the waterfront:

- Identify the chemical constituents present in each discharge for a comprehensive list of pollutants including conventional water quality parameters, bacteria, nutrients, heavy metals and trace organic compounds.
- Estimate the mean contaminant concentrations for each discharge and each type of source.
- Estimate the mean contaminant mass discharges for specific sources and each type of source.
- Provide a measure of uncertainty associated with estimates of the mean concentration and mean mass discharges.

A strong emphasis was placed on the analysis of trace organic compounds which involved special sample collection and analytical procedures. In addition, non-traditional statistical techniques were used in the analysis of data sets containing data at or below the analytical detection limit.

1.4 Significance of this Study

The results from this study will be used to assist in the development, prioritization and design of remedial options and will form a data base by which the effectiveness of remedial measures can be evaluated once implemented.

This study provides a significant amplification of previous studies of direct discharges to the waterfront for the following reasons:

- Outfall studies conducted under the Toronto Area Watershed Management Strategy (TAWMS) were directed mainly towards identifying sanitary sewer cross-connections and collected limited concentration and flow data at each outfall. Several samples are however, required to assess the statistical properties of the data and continuous monitoring is required to evaluate the instantaneous measurement approach.

- Previous outfall studies have been generally limited to conventional water quality parameters including oxygen demanding substances, suspended solids, nutrients, bacteria and a few heavy metals.

- The focus of previous outfall studies has been on outfalls discharging to area tributaries; little information is available for waterfront outfalls.

- Few organic parameters were analyzed in samples collected through previous studies.

- Unsatisfactory analytical detection limits were used for the analysis of priority organic parameters in previous studies of outfalls and WPCP discharges.

- Large volume samples (16 litre), necessary to reduce the analytical detection limit of trace organic compounds, were not used in previous studies .

1.5 Description of Sources

1.5.1 Sewer Outfalls

The Metropolitan Toronto area is serviced mainly by a separated storm sewer system, however a significant area is serviced by a combined sewer system. In a separated system, sanitary sewers are used to convey sanitary sewage to water pollution control plants for treatment and storm sewers are used to convey stormwater runoff from street surfaces to the nearest watercourse. During dry weather periods sources of flow to the storm sewer system include:

- groundwater infiltration,
- industrial cooling water,
- illicit sanitary sewer cross connections,
- infiltration from the sanitary system through leaks in the sewer systems,
- excess surface watering (ie. lawns, washing on paved surfaces, etc.),
- accidental or deliberate spills to road side catchbasins,
- routing of stream flows through storm sewers.

In a combined sewer system, sanitary sewage and stormwater runoff is conveyed in the same pipe to the nearest water pollution control plant for treatment. Flow regulators are used as hydraulic reliefs in the system to divert excess flow (combined sewer overflow), usually generated during periods of wet weather. The flows are usually routed through a storm sewer to the nearest watercourse. During dry weather periods combined sewer overflows can occur as a result of flow surges from the above-mentioned dry weather source inputs to the storm sewer system and:

- improperly set flow regulators or
- flow surges in the collection system (ie. flow surges from pumping stations).

There are over 100 sewer outfalls located along the waterfront. Forty-one of these outfalls were monitored in this study because they were identified as discharging significant flow (greater than 1.0 litre/second) to the waterfront.

It should be noted that while this report is based on 1989 data, the Regional Municipality of Metropolitan Toronto and each waterfront municipality namely; the Cities of Etobicoke, Toronto and Scarborough have been and continue to be actively involved in the identification of pollutant sources and the remediation of dry weather discharges to waterfront outfalls.

1.5.2 Water Filtration Plants

Three water filtration plants are located along the waterfront: the R.L Clark, R.C. Harris and F.J. Horgan Plants. The plants draw water from Lake Ontario and employ a conventional process train of coagulation, flocculation, sedimentation, filtration and chlorination. An aluminum based coagulant is added to facilitate the removal of particulate material in suspension and the water is filtered through dual media (sand and anthracite) filters prior to distribution for potable, commercial and industrial uses. The filters are regularly backwashed to remove the trapped material. The backwash water, containing high concentrations of suspended solids, is routed directly to Lake Ontario through an outfall pipe located several hundred metres offshore at the R.L. Clark plant and near shore at the R.C. Harris plant. At the F.J. Horgan Plant, the solids in the backwash water are removed in a clarifier prior to discharge to Lake Ontario via a drainage ditch. The separated solids are discharged to a dedicated sludge forcemain for treatment at the Highland Creek WPCP.

1.5.3 Water Pollution Control Plants

Three water pollution control plants are geographically located within the Metropolitan Toronto

Waterfront boundaries; the Humber, Main Metro and Highland Creek Plants, from west to east respectively. In addition, the Lakeview WPCP which is located west of the Metropolitan Toronto Waterfront was included in this study because the effluent is discharged through an outfall located offshore, close to the study boundary.

The four plants are conventional activated sludge plants with continuous phosphorus removal. During dry weather conditions, the plants receive sanitary, commercial and industrial waste from within the Metropolitan Toronto area for treatment. The treated effluent is generally chlorinated prior to discharge to Lake Ontario through diffuser outfalls located several hundred meters offshore.

2.0 STUDY APPROACH

This study involved the collection of water samples from the various sources, making flow measurements and then synthesizing the results into statistical summaries of flow, contaminant concentrations and contaminant loadings (mass discharges). The field program was completed in two phases; during the winter and fall of 1989, respectively.

2.1 Water Quality Sampling and Flow Measurements

The sampling locations used in this study are presented in Figure 1.1 and are summarized in Table 2.1. A description of these locations and a summary of the sample collection procedures and flow measurements taken is now presented.

2.1.1 Sewer Outfalls

A criterion of dry weather flow in excess of 1 litre/second was established for the selection of outfalls to be sampled. An initial screening of 103 waterfront outfalls by MOE identified forty-one outfalls as meeting this criteria: twelve in the City of Etobicoke; ten in the City of Toronto; and nineteen in the City of Scarborough.

During each phase of the study, each outfall was initially sampled twice. Flow data and preliminary water chemistry data were used to prioritize sites for additional sampling, which generally involved three additional sets of samples. Four to six outfalls were chosen for the collection of up to eight samples in total to assist in defining the statistical properties of the chemical data sets.

The general criteria used for sampling on a dry weather day was that the discharge flow was estimated to be in excess of 1 litre/second and that not more than 2 millimetres of rainfall or insignificant snow melt had occurred over the previous 48 hour period.

Sampling was usually conducted at the point of discharge to Lake Ontario. In some cases however, the outfalls were submerged below the lake surface and manholes were used to gain access at a point upstream of lake backwater.

Instantaneous flows were calculated from measurements, made at the time of sample collection, of the cross-sectional area of flow and velocity, generally using a portable Montedoro Whitney Flow Meters (WDFM-8). Flow meters were installed at 12 outfall locations during the winter survey. These continuous flow records were used to evaluate the instantaneous flow measurements.

Water samples for chemical analysis were collected as grab samples at the time of flow measurement.

2.1.2 Water Filtration Plants

Backwash water from the dual media filters is the primary source of water discharged from the water filtration plants. Five grab samples were collected from each of the three water filtration plants during the winter and four samples were collected during the fall. Samples of filter backwash were collected at both the R.L. Clark and R.C. Harris plants, at an access point as close to the point of discharge as possible. The samples were collected as sequential grab samples during the initial period of the backwash cycle when the concentration of particulate material is high and then combined to form a composite sample. This approach would tend to provide over-estimates of contaminant concentrations discharged through the backwash.

At the F.J. Horgan plant, backwash water enters a clarifier; the overflow is discharged to Lake Ontario and the underflow containing high solids concentrations is fed to the Highland Creek WPCP. At the F.J. Horgan plant, samples were collected from the clarifier overflow. The contaminant concentrations in the overflow are not expected to vary significantly through the backwash cycle and are therefore representative of the discharge to Lake Ontario.

Plant flow records were obtained for the days sampled and used for the analysis of mean flow and contaminant loading estimates.

2.1.3 Water Pollution Control Plants

The four water pollution control plants were each sampled five times using a grab sample approach in the winter and six times using an automatic sampler during the fall. The automatic sampler was programmed to collect a 20 litre, 24 hour flow weighted (based on average diurnal plant flow characteristics) composite sample. The samples were collected no more frequently than twice weekly using the dry weather criteria established for the sewer outfalls. The samples were collected after effluent chlorination, usually at the last access point prior to discharge; as such they are representative of the plant discharges to Lake Ontario.

The analytical data for the fall composite samples collected were used to compute both mean effluent contaminant concentrations and mass loadings for all parameters except the volatile organic compounds because composite samples are more representative of mean effluent characteristics. Grab samples collected on the day of sample retrieval were used for the analysis of volatile organic compounds.

Plant flow records were obtained for the days sampled and used as the basis for estimating mean dry weather flow and contaminant loadings.

2.2 Parameters Analyzed

The parameters analyzed in this study are classified by the following major groupings:

● general chemistry	(eg. total suspended solids)
● nutrients	(eg. total phosphorus)

- bacteriology (eg. fecal coliforms)
- metals (eg. aluminum)
- chlorobenzenes (eg. 1,2,4 trichlorobenzene)
- organochlorine pesticides & PCBs (eg. lindane)
- chlorophenol pesticides (eg. pentachlorophenol)
- volatile organics (eg. chloroform)
- resins & fatty acids (eg. oleic acid)
- polynuclear aromatic hydrocarbons (eg. anthracene)

With the exception of the large volume trace organics analyses of polynuclear aromatic hydrocarbons (in WPCP samples only), chlorobenzenes, organochlorine pesticides and PCBs, the Ontario Ministry of the Environment's Laboratory Services Branch performed the chemical analysis for all compounds. Analytical methodologies described in MOE (1988) were used in these analyses.

Mann Testing Laboratories performed the chemical analysis of the large volume samples for the above-mentioned trace organic compounds. The analytical procedure involved using a Goulden Extractor for the solvent extraction of the sample. The concentration, cleanup and analysis using a dual column/dual electron capture detector followed the methodology described in MOE (1988).

2.3 Statistical Techniques

Statistical summaries are presented as an estimate of the mean with a measure of variability defined as the 95% confidence interval (ie. the true concentration will lie within this confidence interval 95 times out of 100), wherever possible. Many of the contaminant concentration data sets used in this study are however, left-censored (ie. contain data at or below the analytical detection limit) and statistical evaluation of these data sets requires the use of non-traditional techniques.

Figure 2.1 presents a probability distribution plot of PCBs and suspended solids concentrations, respectively. The two plots are typical of many of the data sets. For some parameters such as suspended solids, almost all the data is above the analytical detection limit and the distribution approximates a straight line when the data is log transformed, indicating the data set is lognormally distributed. For other parameters such as PCBs, most of the data is at or below the detection limit (shown as a series of horizontal points at the detection limit). The data points above the detection limit can, however, be fitted with a sloping line. Other parameters show characteristics between these two extremes, dependent upon the frequency of detection limit values.

Probability distribution estimation (PDE) techniques were used to estimate the mean and corresponding confidence interval for the data sets containing censored data. These techniques use the probability distribution of the non-censored data (data above the detection limit) to estimate the statistical properties of the entire data set. One of these techniques, the maximum likelihood estimation (MLE) method, is widely accepted for the statistical description of left-censored water chemistry data [eg. Cohen (1959), Gilbert (1987) and El-Sharaawi and Dolan (1989)], and was one technique used in this study. It provides an estimate of the mean and standard deviation of the data set by using estimates of the statistical properties of the non-censored data. It is recommended for use when up to 80% of the distribution is censored and where there is a minimum of three to five non-censored values.

Another PDE technique, used in the analysis of data sets which did not meet the criteria for the application of the MLE technique, involved fitting a linear regression of probability with the non-censored data. The regression was used to generate estimates of the censored data which were used in the estimation of the mean and corresponding confidence interval by traditional methods. This approach was generally used when 80 to 90% of the data set consisted of censored values.

In addition, a more traditional approach such as substituting a fraction (generally 1/2) of the analytical detection limit value for those values which were at or below the detection limit was

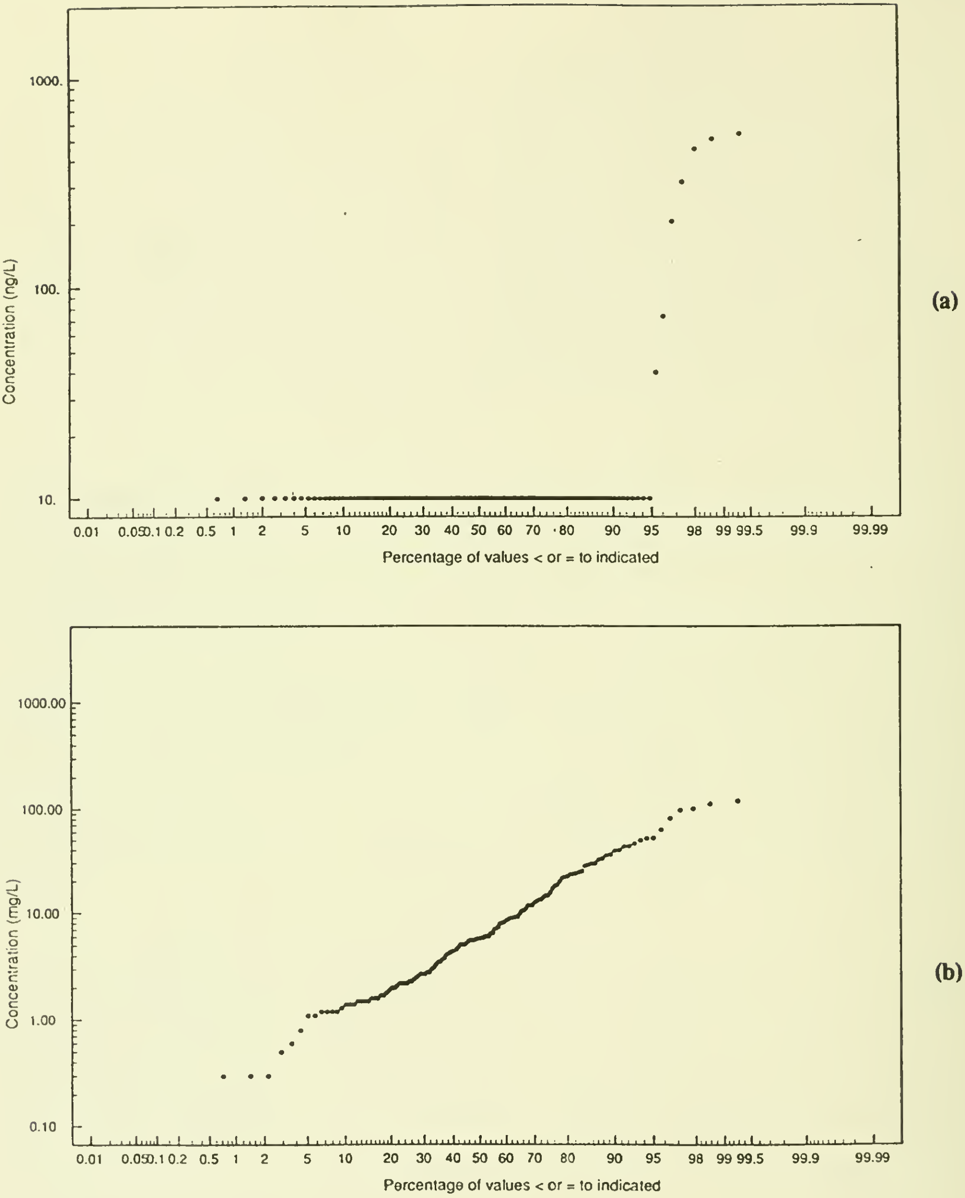


Figure 2.1 Probability distribution for: (a) Total PCBs - MDL=10 ng/L, N=151
(b) Suspended Solids - MDL=0.3 mg/L, N=138

used when the data characteristics did not permit the application of the PDE techniques. This approach was used to provide only mean estimates of the data. Confidence intervals were not presented because they are biased by the substituted data.

Contaminant loadings were estimated by multiplying the mean flow of the data set by the mean concentration value. Confidence intervals were based on the variance of the concentration and flow probability distributions using an estimation procedure suggested by El-Shaarawi (1990).

Accordingly, if the flow and concentration data sets are lognormally distributed the 95% confidence interval of the mean load "L", conditional on the measured flow, can be expressed as follows:

$$\hat{L}\, e^{(-1.96\,\theta)} < L < \hat{L}\, e^{(1.96\,\theta)}$$

where:

$$\theta = \sqrt{\frac{\sigma^2_{\log Q}}{n_Q} + \frac{\sigma^2_{\log C}}{n_C}}$$

σ^2 = *variance*
$\hat{L} = \bar{C} \,X\, \bar{Q}$
n = *number of measurements*
$\bar{C}$ = *mean concentration*
$\bar{Q}$ = *mean flow*
C,Q *are independent*

TABLE 2.1: STATION SUMMARY TABLE

OUTLET NUMBER	STATION LOCATION	CATCHMENT LAND USE^{++}	CATCHMENT AREA (ha)$^{++}$	MOE STATION NUMBER
CITY OF ETOBICOKE				
L102	end of 40th Street	RES	28	05 0073
L103^{+}	end of 37th Street	RES/IND	10	05 0074
L105	end of Long Branch Avenue	RES/COM	13	05 0075
L202	end of 28th Street	RES/IND	67	05 0076
L204^{+}	south end of R.L. Clark Filtration Plant	IND/RES/INST	380.0	05 0039
L301	end of 12th Street	RES	11	05 0077
L303	end of 9th Street	RES	19	05 0078
L308^{+}	end of 2nd Street	IND/RES/COM	72.0	05 0079
L309^{+}	end of Sand Beach Road	IND/RES	54	05 0080
L401	end of Royal York Road	RES	20	05 0036
L403C	end of Norris Crescent	RES/IND/INST	195.0	05 0037
L405A	east side of Mimico Creek at Lakeshore Blvd	OPEN	-	05 0041
CITY OF TORONTO				
W13^{+}	Glendale Avenue, south of Parkdale Road			05 0081
W6^{+}	Cowan Avenue north of Springhurst Avenue			05 0082
W5^{+}	CNE, east of Dufferin Street			05 0083
TH15	Wellington Street west of Walnut Avenue			05 0084
TH14^{+}	Portland Street north of Front Street W.			05 0085
TH13	Spadina Avenue and Front Street			05 0086
E12-A	Woodfield Avenue, north of Dundas Street			05 0087
E12-B	Ashdale Avenue north of Dundas Street			05 0088
E11	Greenwood Race Track and Eastern Avenue			05 0089
E5^{+}	Glen Manor Drive west of Bonfield Avenue			05 0090
E1	Nursewood Road south of Queen Street			05 0091
CITY OF SCARBOROUGH				
914	MH at end of Fallingbrook Drive	RES	80	05 0092
908	MH at end of Lakehurst Drive	INST/OPEN/RES	149	05 0093
906	MH at base of Wynview Court	RES/OPEN/INST	27	05 0094
900	MH at Undercliff Rd. & Chine Dr.	RES/INST/OPEN	161	05 0095
900-B^{+}	MH at end of Cecil Drive	RES	102	05 0096
904	end of Brimley Road	RES/OPEN	181	05 0098
918-A	square pipe - Kingston Rd. west of Bellamy	COM/RES	-	05 0099
918-B	round pipe - Kingston Rd. west of Bellamy	COM/RES	-	05 0100
901	MH at end of Livingston Road	RES	181	05 0101
903-A	MH at Guildwood Prkwy. west of Morningside	RES	-	05 0102
903-B	MH at Morningside Ave. south of Cumber Ave.	RES	-	05 0103
935	ravine south of CNR east of Morningside	RES	-	05 0104
933^{+}	headwall of Rohm Haas Plant at 935	IND	-	91 0001
929	end of Beechgrove Drive at Bluffs	IND/OPEN	-	05 0105
925	ditch north of CNR at Beechgrove Drive	IND/OPEN	174	05 0106
919	end of Centennial Road	RES	-	05 0107
301	Centennial Creek:ravine upstream of 919	RES	-	05 0108
913^{+}	MH at end of Port Union Road	RES	103	05 0109
927	MH at end of Starspray Blvd.	RES	120	05 0110

TABLE 2.1 (cont'd): STATION SUMMARY TABLE

OUTLET NUMBER	STATION LOCATION	MOE STATION NUMBER
WATER POLLUTION CONTROL PLANTS		
Lakeview	final effluent at Lakeview WPCP	03 0027
Humber	final effluent at Humber WPCP	03 0018
Main	final effluent at Toronto Main WPCP	03 0022
Highland	final effluent at Highland Creek WPCP	03 0028
WATER FILTRATION PLANTS		
R.L. Clark	backwash water from R.L. Clark WFP (Common Conduit)	09 0040
R.C. Harris	backwash water from R.C. Harris WFP (Individual Filter)	09 0041
F.J. Horgan	backwash clarifier overflow from Easterly WFP	09 0042

NOTE:

MH - Manhole
+ - Locations of Continuous Flow Monitoring.
++ - Blanks indicate that information is unavailable.
RES - Residential
COM - Commercial
IND - Industrial
INST - Institutional

3.0 FLOW CHARACTERISTICS

A summary of the total daily flows for the three types of sources and average daily flows for individual sources considered in this study, respectively, is presented in Figure 3.1. The flow contribution from the outfalls and water filtration plant backwash discharges are similar, each about 32 million litres/day (MLD). The combined flow from the WPCPs is two orders of magnitude larger at 1660 MLD.

3.1 Sewer Outfalls

Forty-one outfalls were originally identified as discharging significant flow (estimated to be in excess of 1 litre/second). However, in many instances the outfalls were dry or the flow was marginal and measurements were not taken. Flow summaries are presented in Figure 3.1 for 31 outfalls where at least three flow measurements were taken. For these outfalls, the mean flows vary from approximately 0.1 MLD to 4.0 MLD.

The average flow rate was estimated to be about 0.75 MLD for all outfalls monitored. The average dry weather flow for all outfalls discharging to the waterfront is however, much smaller because a substantial number of outfalls (62) were dry. During the sampling period of this study, outfall L308 (City of Etobicoke) contributed the largest discharge of 4.5 MLD. Nineteen outfalls had mean flow rates in excess of 1.0 MLD. They included: L103, L202, L308 and L405 in the City of Etobicoke; W13, W5, TH15, TH14, E12B, and E5 in the City of Toronto and; 914, 906, 900A, 901, 929, 919, 301, 913 and 927 in the City of Scarborough.

On a municipality basis, 46% (14.8 MLD) of the total dry weather flow originated from 12 outfalls in the City of Etobicoke, 25% (8.2 MLD) originated from 11 outfalls in the City of Toronto and 29% (9.2 MLD) originated from 21 outfalls in the City of Scarborough.

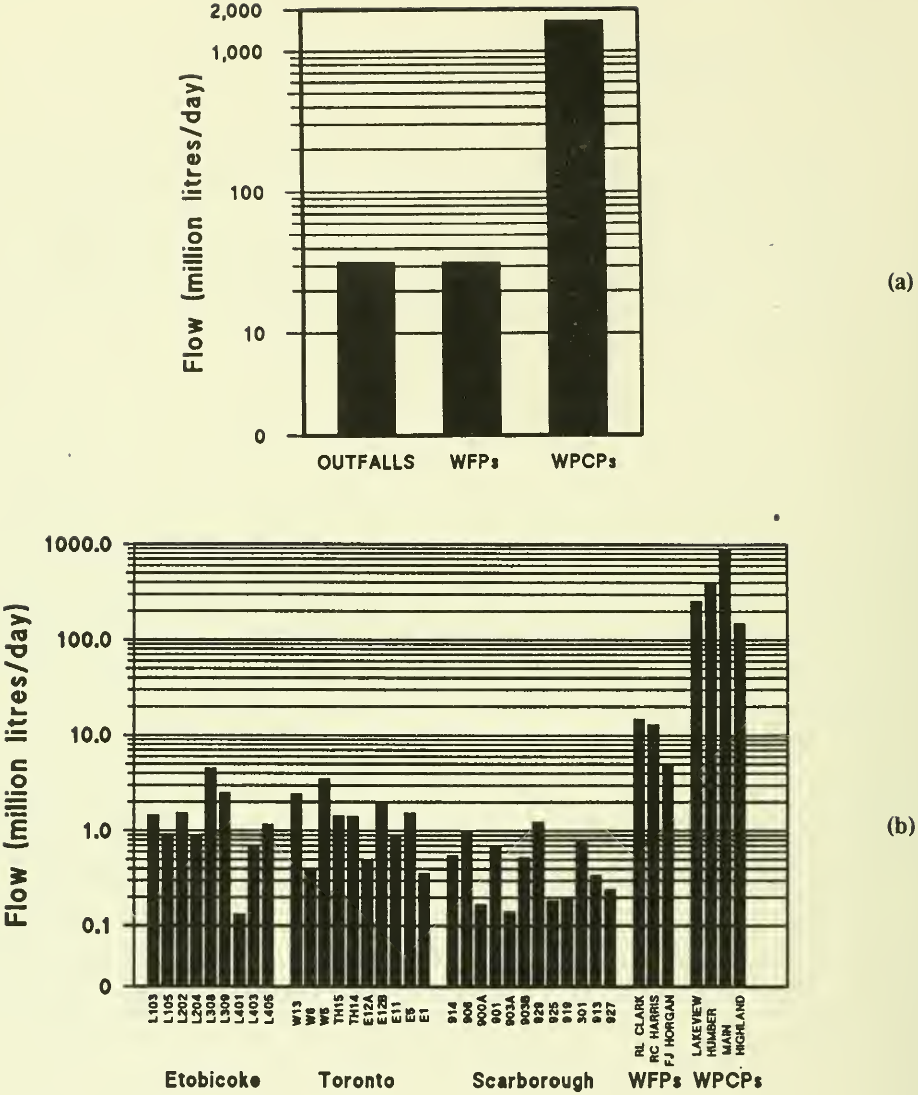


Figure 3.1 Dry weather flow contributions: (a) average total daily flow by source type, (b) average daily flow by source

3.1.1 Comparison with Continuous Flow Records

Continuous flow monitoring data collected during the winter survey was obtained from 13 outfalls locations: L103, L204, L308, L309, W13, W6, W5, TH14, E5, 900A, 900B, 933 and 913. The data was partitioned into dry and wet weather components by screening the flow record using precipitation and temperature data collected from Environment Canada's Toronto Bloor Street Meteorological Station. Mean estimates from the dry weather continuous data were compared to those estimated using the instantaneous measurements from this study. The ratio of the average estimated from the continuous recordings to that generated using instantaneous measurements varied between 0.5 to 2.0 for all but two sites. Generally, the flow estimate based on instantaneous measurements was within one standard deviation of the mean estimated using the continuous measurements, indicating that there is generally good agreement between the two sets of measurements.

3.1.2 Comparison Between Fall and Winter Flow Data

The mean flow estimates based on instantaneous measurements taken at each sewer outfall during the winter and fall, respectively, are presented in Table 3.1. The total discharge flow for all outfalls monitored was substantially less in the fall than during the winter. As well, more outfalls were dry during the fall sampling period than the winter sampling period. Plausible explanations for these differences include: (i) snow melt as an additional source of flow during the winter dry periods and (ii) higher groundwater levels in the winter provided a source of water for infiltrating the storm sewers.

The flow summary for the two seasons on a municipality basis is as follows:

	WINTER	FALL
Scarborough	9.2 MLD (28%)	2.5 MLD (10%)
Toronto	8.2 MLD (25%)	9.0 MLD (37%)
Etobicoke	15. MLD (47%)	13. MLD (53%)
TOTAL:	32.5 MLD (100%)	24.5 MLD (100%)

The dry weather flow rates for both Toronto and Etobicoke are similar, for the winter and fall periods, within the confidence limits of the data (ie. the estimates are considered to be similar if the confidence intervals overlap), assuming a normal distribution. However in the City of Scarborough, the flow rates during the two seasons were found to be significantly different. In addition, there are more dry outfalls in Scarborough during the fall (10) than in the winter (4) whereas all outfalls with significant flow during the winter in Etobicoke and Toronto were also flowing during the fall.

3.2 WFP and WPCP Flows

Flow data for each of the WFPs and WPCPs are presented graphically in Figure 3.1 and tabulated in Table 3.2 for the days of sampling.

The R.L. Clark and R.C. Harris WFPs have the largest average daily backwash discharge flow rates at 15 and 13 MLD, respectively for the days sampled during the winter survey. The F.J. Horgan plant averaged about one-third of the other two plants (5 MLD). The average daily effluent flow for the days sampled during the winter survey at Lakeview, Humber, Main and Highland Creek WPCPs were 256, 388, 865 and 149 MLD, respectively.

Flow data collected for the WFPs and the WPCPs during the winter survey were compared to the fall data and found to be similar at a 5% level of significance, respectively.

TABLE 3.1: COMPARISON OF AVERAGE INSTANTANEOUS DRY WEATHER FLOWS FOR EACH OUTFALL BY SEASON

	Winter Flows		Fall Flows	
	Number of Measurements	Mean Flow (MLD)*	Number of Measurements	Mean Flow (MLD)*
Scarborough Outfalls				
900-A	1	.173	4	.167
901	4	1.18	4	.192
903-A	2	.143	0	0
903-B	3	.827	2	.087
904	1	.0691	0	0
906	4	1.91	4	.111
908	1	.0691	0	0
913	3	.343	0	0
914	2	.553	0	0
918-A	0	0	2	.0864
919	2	.194	0	0
925	2	.190	6	.184
927	2	.134	1	.467
929	4	1.81	3	.476
933	2	.769	0	0
301	2	.795	2	.710
	Mean	0.482	Mean	0.130
	Std.**	0.596	Std.**	0.204
	n	19	n	19
Toronto Outfalls				
E1	1	.233	2	.425
E5	5	1.67	5	1.410
E11	4	.953	8	.826
E12-A	3	.855	5	.295
E12-B	5	.363	5	.317
TH14	5	1.600	7	1.300
TH15	2	.372	2	.350
W5	5	.351	6	.292
W6	5	.461	5	.293
W13	5	1.37	5	3.47
	Mean	.748	Mean	0.816
	Std.**	.580	Std.**	0.987
	n	11	n	11

TABLE 3.1 (cont'd): COMPARISON OF AVERAGE INSTANTANEOUS DRY WEATHER FLOWS FOR EACH OUTFALL BY SEASON

	Winter Flows		Fall Flows	
	Number of Measurements	Mean Flow (MLD)*	Number of Measurements	Mean Flow (MLD)*
Etobicoke Outfalls				
L103	8	2.54	6	1.26
L105	4	1.03	1	.487
L202	5	1.69	4	1.35
L204	8	1.25	7	.402
L308	6	4.19	5	4.90
L309	8	1.84	5	3.55
L401	4	.0929	4	.174
L403C	4	.914	4	.457
L405A	6	1.51	5	.753
	Mean	1.25	Mean	1.11
	Std.**	1.25	Std.**	1.55
	n	12	n	12
All Outfalls				
	Mean	.772	Mean	.590
	Std.**	.873	Std.**	1.04
	n	42	n	42

* MLD: Million litres/day.

** Std = Standard deviation based upon normal distribution.

TABLE 3.2: COMPARISION OF WINTER AND FALL FLOW DATA FOR WPCPs AND WFP BACKWASH

	Winter Survey		Fall Survey	
WPCPs (MLD)	No. of Measurements	Flow (MLD)	No. of Measurements	Flow
Lakeview	5	256	11	265
Main	5	865	17	711
Humber	5	388	8	374
Highland	5	149	10	171
TOTAL		1658		1521

	Winter Survey		Fall Survey	
WFPs (MLD)	No. of Measurements	Flow (MLD)	No. of Measurements	Flow
R.C. Harris	5	12.7	4	12.2
R.L. Clark	5	14.6	4	13.6
F.J. Horgan	5	4.7	4	3.9
TOTAL		32.0		29.7

4.0 CONTAMINANT CONCENTRATION CHARACTERISTICS

4.1 Frequency of Detection

The frequency of detection for water quality parameters in which at least 20 percent of the samples collected from either the WPCPs or sewer outfalls were above the analytical detection limit are presented in Table 4.1. The analytical detection limit and number of samples analyzed is also included.

Conventional water quality parameters such as total suspended solids, biochemical oxygen demand, bacteria, and nutrients had the highest level of detection frequency. These parameters were detected in 90 to 100% of the samples collected.

The following is a list of non-conventional parameters which were detected in more than 20% of the samples collected from the WPCPs and outfalls in either the fall or winter surveys:

Metals

Aluminum
Barium
Cadmium
Chromium
Copper
Iron
Lead
Manganese
Mercury
Nickel
Silver
Zinc

Chlorophenol Pesticides

Pentachlorophenol

Phenoxyacid Pesticides

2,4 Dichlorophenoxybutyric
2,4 DP

Volatile Organics

Chlorodibromomethane
Chloroform
Tetrachloroethane
1,1,1 Trichloroethane
Trichloroethylene

Organochlorine Pesticides

Alpha - BHC
Gamma - BHC
Dieldrin
1,2,4 Trichlorobenzene
1,2,3 Trichlorobenzene
1,2,3,4 Tetrachlorobenzene
1,2,3,5 Tetrachlorobenzene
Hexachlorobenzene
Hexachlorobutadiene
Hexachloroethane
2,6,A Trichlorotoluene

Resins and Fatty Acids

Oleic Acid
Palmitic Acid
Stearic Acid

Additional parameters which were only detected in WPCPs with a detection frequency greater than 20% include the following:

Organochlorine Pesticides

1,3,5 Trichlorobenzene
Pentachlorobenzene

Volatile Organics

Bromochloromethane

Polynuclear Aromatic Hydrocarbons

Acenaphthene
Anthracene
Benzo (b) Fluoranthene
Chrysene
Fluoranthene
Fluorene
Naphthalene
Phenanthrene
Pyrene

A true comparison of detection frequencies for polynuclear aromatic hydrocarbon (PAH) compounds is not possible because lower detection limits (by 2 to 3 orders of magnitude) were used to analyze WPCP samples than were used in sewer outfall samples.

This list of parameters with relatively high detection frequencies should be considered in the selection of target compounds for future monitoring programs directed at dry weather sewer outfall discharges and WPCP effluents.

4.2 Comparison of Contaminant Concentrations Between Discharges

Mean contaminant concentrations for each sewer outfall, WFP and WPCP considered are presented in Figures 4.1 to 4.3. Only those outfalls which were sampled at least three times through the winter and fall surveys combined, are presented in the summary. Figure 4.1 presents mean concentration estimates for conventional water quality parameters including suspended solids, fecal coliform bacteria and total phosphorus. Figure 4.2 includes mean estimates for heavy metals including aluminum, copper, iron and zinc. Figure 4.3 presents mean estimates for organic contaminants including phenolics, lindane, dieldrin and 1,2,4 trichlorobenzene.

Data for the outfalls are presented by municipality and by relative geographic location, from west to east, along the waterfront. Of the original 103 outfalls identified along the waterfront, 31 locations where flow in excess of the 1.0 litre/second criteria permitted the collection of at least three samples during the winter and fall surveys are presented: 9 in the City of Etobicoke, 10 in the City of Toronto and 12 in the City of Scarborough. The WFPs and WPCPs are grouped separately and also presented by relative geographic location, from west to east. The Provincial Water Quality Objective (PWQO) or Guideline (PWQG) (Ministry of the Environment, 1991) has been included for those parameters where one exists.

The variability associated with mean concentration estimates is usually several orders of magnitude. For this reason the estimates are presented using a logarithmic scale.

The mean concentrations for most outfall discharges are in exceedance of Provincial Water Quality Objectives or Guidelines (PWQO/Gs) for many water quality parameters including fecal coliforms, total phosphorus, aluminum, copper, iron and phenolics. Outfall discharge concentrations are however, lower than PWQOs for three organic parameters presented:

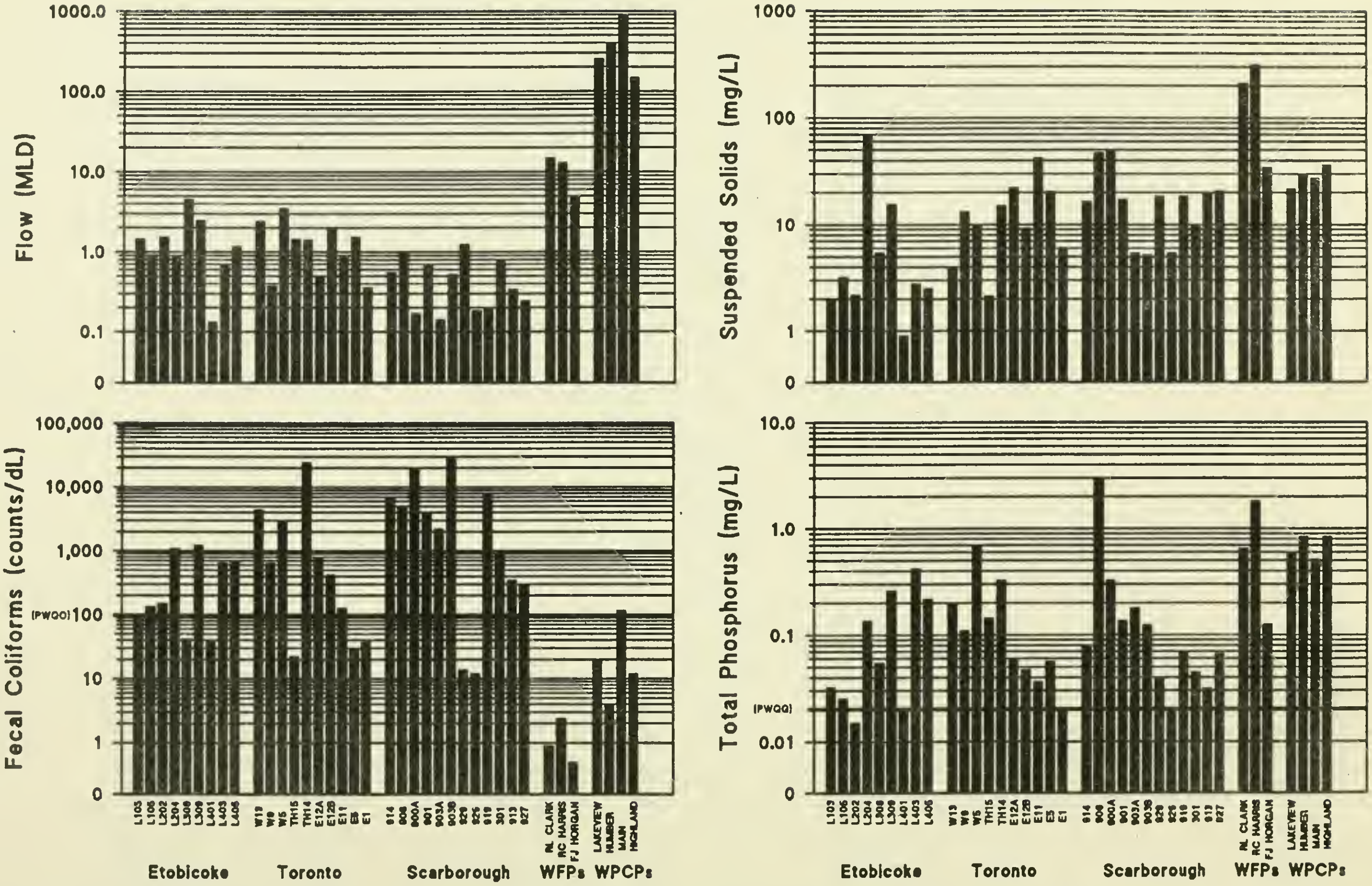


Figure 4.1 Mean discharge flows and contaminant concentrations by source for general water quality parameters.

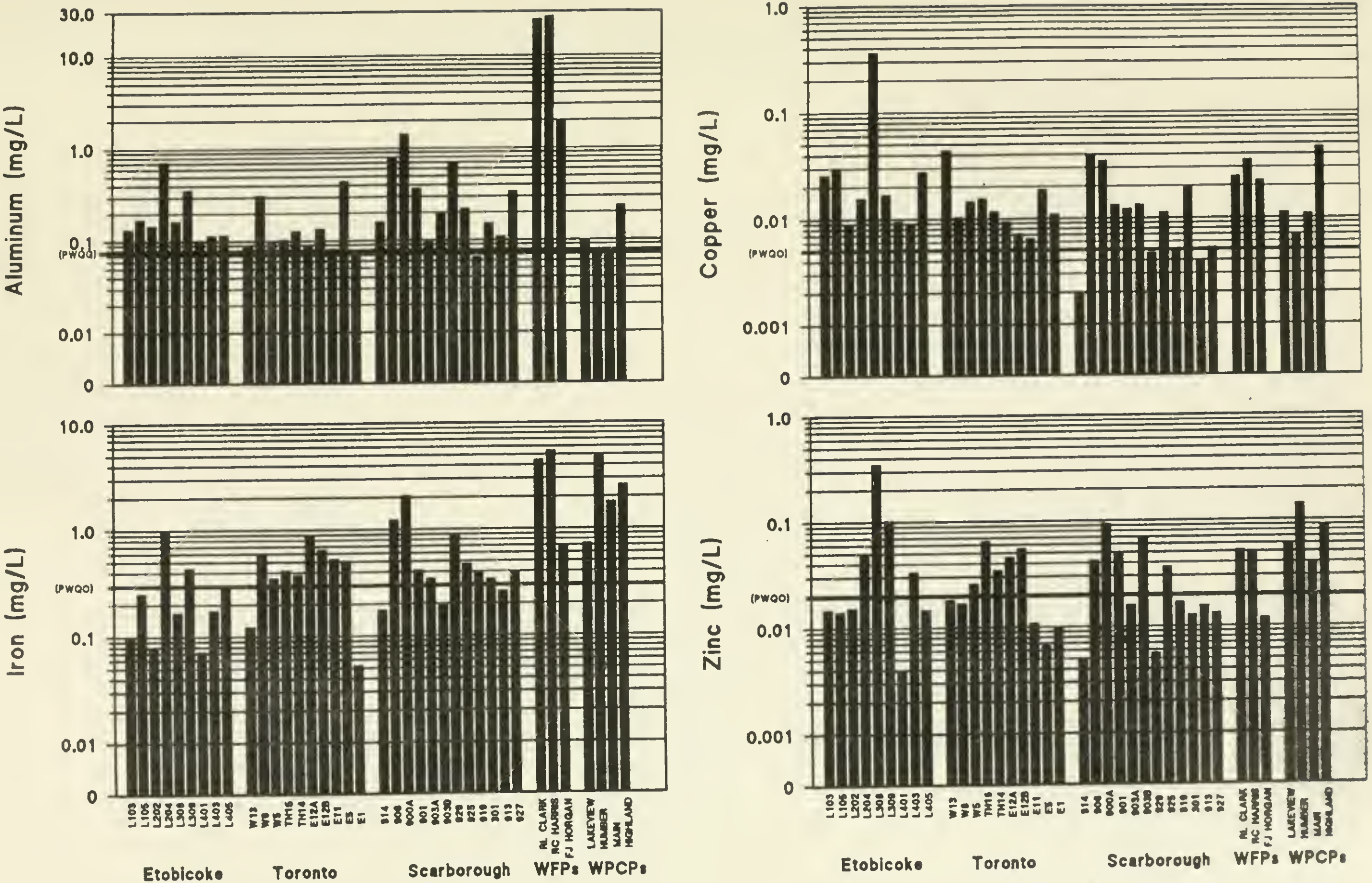


Figure 4.2 Mean contaminant concentrations by source for heavy metals.

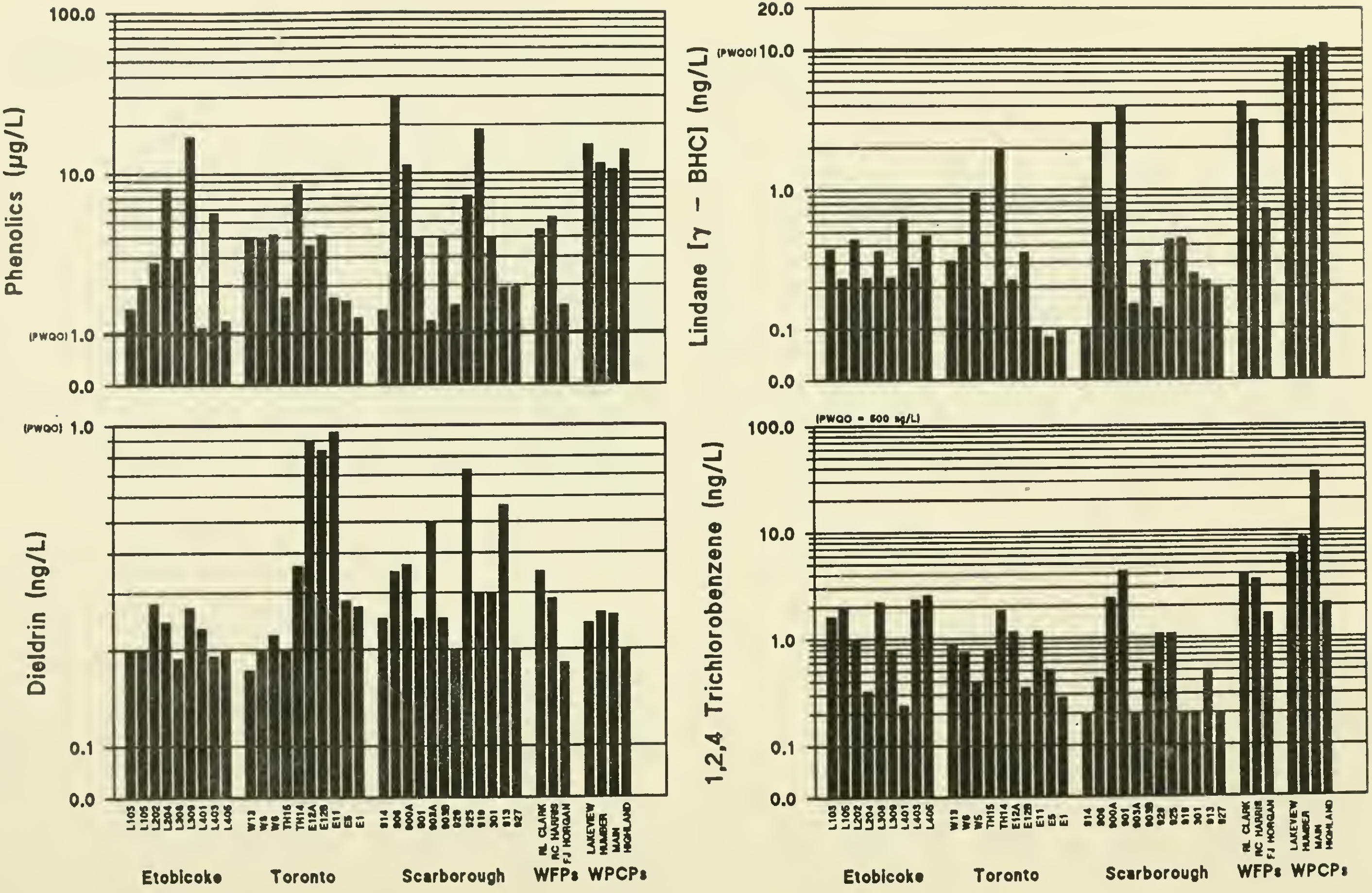


Figure 4.3 Mean contaminant concentrations by source for organic parameters.

lindane, dieldrin, and 1,2,4 trichlorobenzene. With the exception of fecal coliforms, outfall discharges are generally lower in contaminant concentration than WPCPs and WFPs. Concentrations of suspended solids, aluminum, copper, zinc, phenolics and dieldrin for specific outfalls are much larger than those observed from the WFPs or WPCPs. While the discharge from a particular outfall may be higher in concentration for one parameter, the discharge is not necessarily higher in concentration for other parameters in the same group. For example, outfall L308 has the highest concentrations of copper and zinc yet concentrations of aluminum and iron are lower than other outfalls. Similarly, outfalls E12A, E12B and E11 show higher concentrations of dieldrin than other outfalls, yet concentrations of phenolics, lindane and 1,2,4 trichlorobenzene are lower than other outfalls. These differences may be due to local land use activities and the nature of the source of flow to that outfall (ie. cooling water versus groundwater).

The three WFPs exceed PWQO/Gs for total phosphorus, aluminum, copper, iron and phenolics. It should be noted however, that measured concentrations at the WFPs are over-estimates because of the sampling procedure used. The backwash from each plant is lower than the PWQOs for fecal coliforms, lindane, dieldrin and 1,2,4 trichlorobenzene. The removal of suspended solids from the backwash water at the F.J. Horgan plant produces much lower concentrations, by approximately one order of magnitude. Aluminum concentrations from the WFPs are significantly larger (by two orders of magnitude at the R.L. Clark and R.C. Harris plants) than the WPCPs or sewer outfalls. This is attributed to the aluminum based coagulants used in the treatment process.

WPCP effluent concentrations are generally higher than PWQOs for most of the parameters presented. Generally, the concentrations discharged by different plants are similar. However, concentrations of total phosphorus, iron and zinc are larger at the Humber Plant. The Main Plant has slightly larger concentrations of fecal coliform bacteria and 1,2,4 trichlorobenzene. Concentrations of aluminum and copper are larger at the Highland Creek Plant.

4.2.1 Ranking Discharges by Flow and Contaminant Concentrations

A ranking of sources based on flow and selected water quality parameter is presented in Table 4.2 by discharge type. The following eleven parameters are selected for ranking because they are representative of the various classes of water quality parameters considered: fecal coliforms, suspended solids, total phosphorus, aluminum, copper, iron, zinc, phenolics, lindane, dieldrin and 1,2,4 trichlorobenzene. Outfall discharges are presented in Tables 4.2a to 4.2c for the Cities of Etobicoke, Toronto and Scarborough, respectively. These three tables should be visualized together in the overall presentation of outfall results. WFPs and WPCPs are presented in Table 4.2d.

Tables 4.2a to 4.2c present a ranking of outfalls which can be used to identify higher priority outfalls based on discharge flow and concentration. The tables are structured such that two columns of boxes are provided for those parameters which have applicable PWQO/Gs where; one column is used to identify the 10 highest concentrations with shaded boxes, each containing a number (representing the relative ranking, in descending order of concentration, among all the waterfront outfalls); and the other column is used to identify those discharges exceeding PWQO/Gs with shaded boxes, each containing an asterisk. Only one column of boxes is used for those parameters which do not have applicable PWQO/Gs. This column is used to identify those discharges with the 10 highest concentrations using a shaded box and a number (representing the relative ranking, in descending order, among all the waterfront outfalls).

The outfall discharges have been ranked by scoring each discharge (a score of one is represented by each shaded box in Tables 4.2a to 4.2c) where:

- a score of one is assigned to each of 10 outfalls (among all waterfront outfalls) with the highest flows;
- a score of one is assigned to each of 10 outfalls (among all waterfront outfalls) with the highest concentrations;
- a score of one is assigned to each discharge in exceedance of a PWQO/G for a

given parameter.

Table 4.2 also presents columns of "Total Score" and "Net Rank" where: the "Total Score" represents the sum of all scores assigned to a given discharge (total number of shaded boxes assigned where maximum Total Score is 22); and the "Net Rank" is a ranking of total scores in descending order (where equal total scores were assigned equal ranks and a Net Rank of 1 signifies highest priority) are also presented in Table 4.2. While this analysis is somewhat qualitative, the Total Score and Net Rank values provide a measure of the relative significance of each outfall discharge and a ranking for the prioritization of outfalls requiring remediation.

In Table 4.2, the 10 outfalls with the largest flows include four outfalls located in the City of Etobicoke and six outfalls located in the City of Toronto. In descending order of flow these outfalls are: L308, W5, L309, W13, E12B, E5, L202, L103, TH15 and TH14.

The Net Rank values presented in Table 4.2 provide an overall ranking of discharges based on flow and contaminant concentrations. Eleven higher priority outfalls are identified by selecting discharges with a Net Rank of 5 or lower and include: 2 outfalls in the City of Etobicoke, 5 outfalls in the City of Toronto and 4 outfalls in the City of Scarborough. In descending order of priority these outfalls are:

NET RANK	OUTFALLS
1	900A
2	906
3	TH14
4	L202, L309, E12A, E12B, 901
5	W5, E5, 925

Outfalls with higher flows are not necessarily ranked higher overall. For example, while outfall L308 in the City of Etobicoke has the largest flow it is ranked only 8 (maximum is 12) in the overall analysis. Conversely, outfalls 900A and 906 in the City of Scarborough are not ranked among the 10 highest flows yet they are ranked highest in priority, because of high contaminant concentrations, in the overall analysis.

With the exception of sewer outfall E1 in the City of Toronto, each discharge is in exceedance of PWQOs for several parameters. As observed in previous figures, Table 4.2 shows that virtually all outfall discharges are in exceedance of the PWQO/Gs for fecal coliforms, total phosphorus, aluminum, copper and phenolics and most discharges are in exceedance of the PWQO for iron.

Table 4.2d presents a similar ranking for the three WFPs and four WPCPs to that presented for the outfalls in Tables 4.2a to 4.2c. Within each grouping (eg. WFPs), each discharge is ranked in decreasing order of concentration (where a numeric value of 1 is assigned to the discharge with the highest value) and each exceedance of a PWQO/G is identified with an asterisk. However, values of Total Score and Net Rank are not provided for WFPs and WPCPs because each source exceeds PWQO/Gs for most of the parameters considered and the relative significance of these sources is based largely on flow and site specific conditions at the point of discharge.

Contaminant concentrations among the WFPs are consistently lower at the F.J. Horgan Plant. This again demonstrates the effects of the improved treatment technology applied to the backwash flows. Concentrations for conventional parameters are generally higher at the R.C. Harris Plant, whereas, concentrations for the organic parameters are generally higher at the R.L. Clark Plant.

Among the WPCPs, higher concentrations are observed for 5 parameters at the Highland Creek Plant; 3 parameters at the Humber Plant; 2 parameters at the Main Plant; and 1 parameter at the Lakeview Plant. Ranking these plants by the number of parameters in exceedance of PWQO/G from most to least are: Main, Highland Creek, Lakeview and Humber.

4.3 Comparison of Contaminant Concentrations Between Types of Discharges

A summary of mean contaminant concentrations observed in each type of discharge, for those parameters which were detected at a frequency of at least 20% in either sewer outfall or WPCP samples collected, is presented in Table 4.3. The table also presents the Provincial Water Quality Objective or Guideline and the Metropolitan Toronto Sewer Use Bylaw (Metropolitan Toronto, 1989) limits for discharges to storm sewers, where available. Typically, the Bylaw limits for discharges to storm sewers are within a factor of two to five of PWQOs, reflecting the fact that only a modest amount of dilution is available before acceptable ambient concentrations are achieved.

Mean contaminant concentrations for 18 of these compounds are presented in Figures 4.4 to 4.6 for the three sources. Data in these figures includes the mean estimates and the corresponding 95% confidence interval. Both winter and fall data are presented for the sewer outfalls and fall data is presented for the WFPs. Fall data for the WPCPs are presented because flow weighted composite samples are considered more representative of daily average effluent characteristics than the grab samples of the winter data set.

The range of mean concentration estimates is usually several orders of magnitude. For this reason the estimates are presented using a logarithmic scale.

Figure 4.4 presents mean concentration estimates for six conventional water quality parameters; suspended solids, fecal coliform bacteria, total phosphorus, total kjeldahl nitrogen, biochemical oxygen demand and phenolics. Figure 4.5 presents mean estimates for six heavy metals; aluminum, copper, iron, manganese, nickel and zinc. Figure 4.6 presents mean estimates for six organic contaminants; dieldrin, lindane, 1,2,4 trichlorobenzene, 1,2,3,5 tetrachlorobenzene, pentachlorobenzene and hexachlorobenzene.

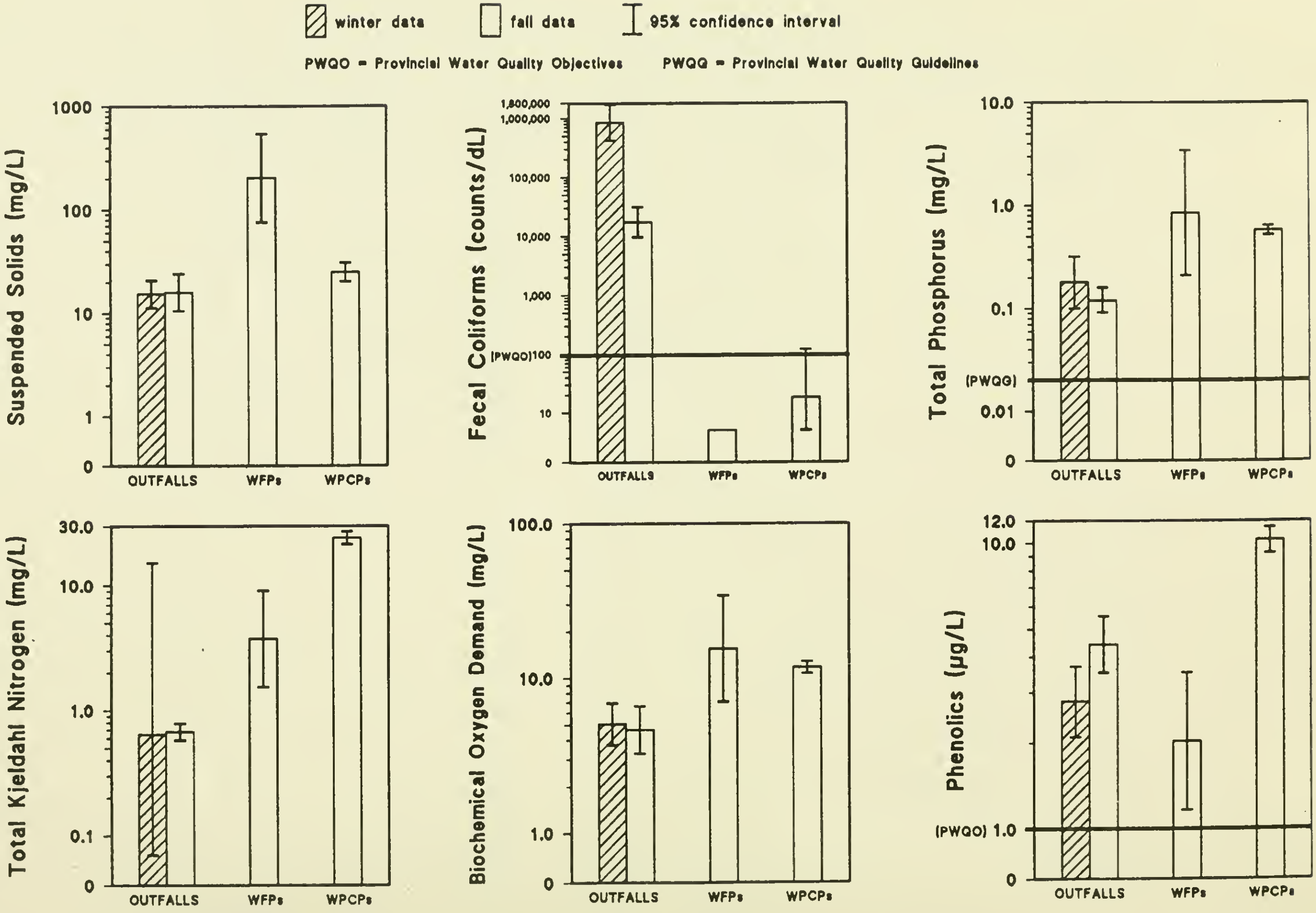


Figure 4.4 Mean contaminant concentrations with the 95% confidence interval for conventional water quality parameters.

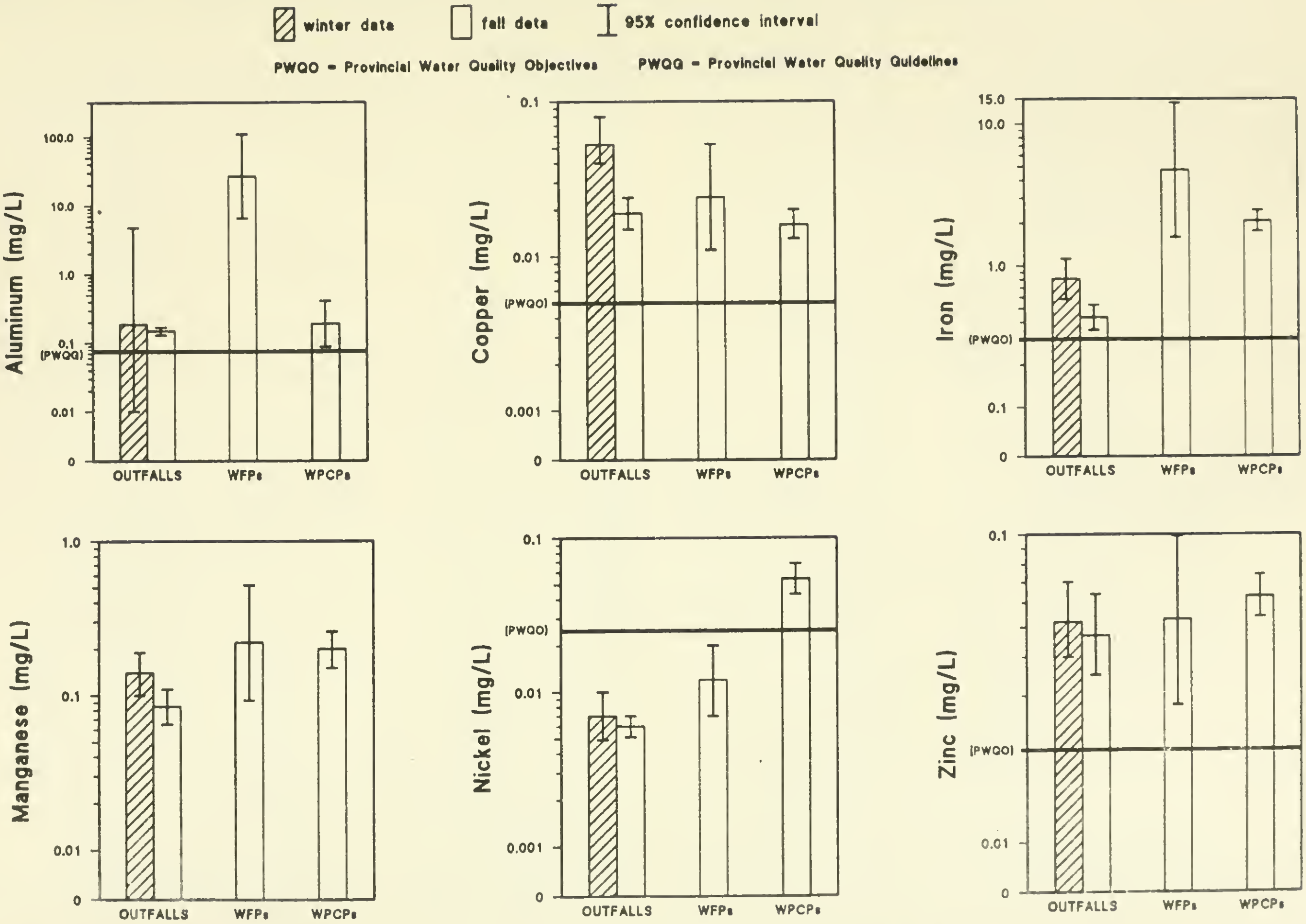


Figure 4.5 Mean contaminant concentrations with the 95% confidence interval for heavy metals.

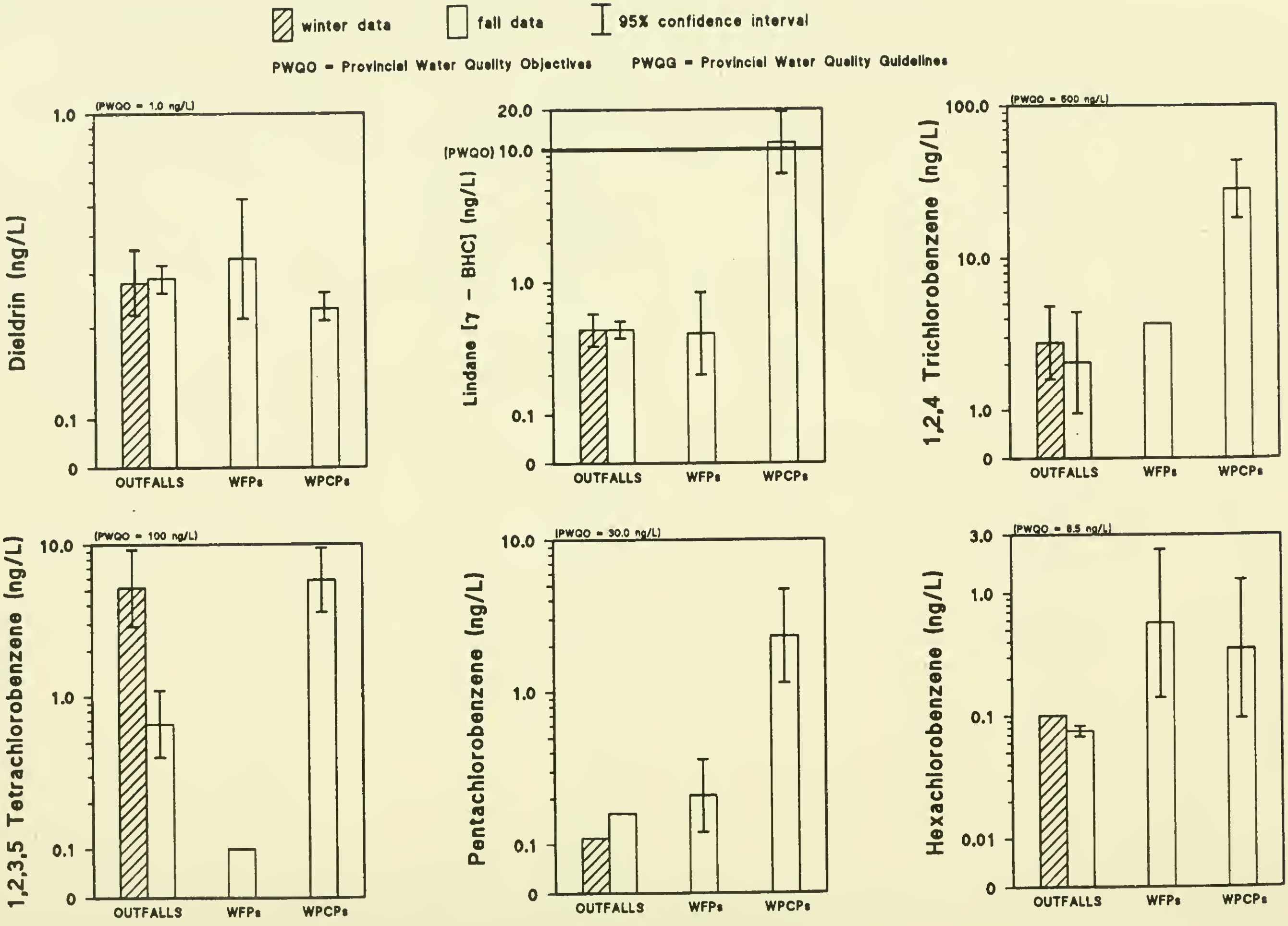


Figure 4.6 Mean contaminant concentrations with the 95% confidence interval for organic parameters.

The mean concentrations for the outfalls exceed PWQO/Gs for many water quality parameters including fecal coliform bacteria, total phosphorus, phenolics, aluminum, copper, iron, zinc and pentachlorophenol. Outfall discharges are however, lower than PWQOs for all organochlorine pesticides which have PWQOs. With the exception of fecal coliforms, contaminant concentrations in outfalls are generally lower than those measured in WFPs and WPCPs. In comparison to WPCPs, concentrations in outfalls are similar for suspended solids, aluminum, copper, manganese, zinc, dieldrin and 1,2,3,5 tetrachlorobenzene.

There are significant seasonal differences in outfall contaminant concentrations for a number of parameters. This can be determined by comparing estimates of the mean and corresponding confidence intervals (ie. the estimates are considered to be similar if the confidence intervals overlap). For example, fecal coliform, copper, iron, manganese and 1,2,3,5 tetrachlorobenzene are higher in the winter data set. Conversely, concentrations of phenolics are higher in the fall data set.

The WFP contaminant concentrations exceed PWQO/Gs for total phosphorus, phenolics, aluminum, copper, iron and zinc. WFP concentrations are lower than PWQOs for the six organic contaminants presented in Figure 4.6. It should be noted however, that the observed concentrations measured at the WFPs are over-estimates because of the sampling procedure used. In comparison to WPCPs, WFPs discharge higher concentrations of suspended solids, aluminum and iron.

WPCP effluent concentrations are generally higher than those measured for sewer outfalls and WFPs and are higher than PWQO/Gs for most of the parameters presented. With the exception of lindane, WPCP effluent concentrations for trace organic compounds are lower than the PWQOs. However, a thorough comparison is not possible because PWQOs are not available for many organic parameters (ie. polynuclear aromatic hydrocarbons). In comparison to outfall discharges, WPCP effluent concentrations are an order of magnitude higher for total kjeldahl nitrogen, phenolics, iron, nickel, lindane, 1,2,4 trichlorobenzene, pentachlorobenzene and hexachlorobenzene.

The Metropolitan Toronto Sewer Use Bylaw for discharges to storm sewers, presented in Table 4.3, provides target concentrations for a limited number of more conventional water quality parameters and some heavy metals such as total suspended solids, biochemical oxygen demand, fecal coliform bacteria, cadmium, copper, chromium, lead, mercury, nickel and zinc. None of the discharge types are in exceedance of the limits for biochemical oxygen demand, lead and mercury. In addition, the WFPs are in compliance for fecal coliform bacteria and the WPCPs are in exceedance for nickel.

4.4 List of Parameters Which Have Applicable Criteria and Higher Frequency of Detection

A list of parameters analyzed in this study for which PWQO/Gs or Metro Sewer Bylaw targets are available and which were detected in at least 20 percent of the outfall or WPCP samples are presented in Table 4.4. This list is intended to provide some guidance in prioritizing the selection of parameters for future monitoring studies. A full list of water quality parameters detected with a frequency greater than 20 percent but which do not necessarily have applicable target concentrations is presented in Section 4.1. Discharges with mean contaminant concentrations in excess of the PWQO/Gs or Metro's Bylaw (if PWQO/G is not available) are identified in Table 4.4 by the shaded boxes.

For parameters where both PWQO/G and Bylaw targets are available, the PWQO/Gs which are lower in magnitude were used to determine exceedances. Based on this presentation, the chemical analyses for the following parameters are identified as priorities for future regulatory monitoring: phenols, total phosphorus, total suspended solids, fecal coliforms, aluminum, cadmium, copper, iron, lead, silver and zinc (nickel and lindane should also be added for WPCP monitoring).

It is emphasized however, that a full evaluation of the significance of contaminant concentrations measured in this study is not possible because PWQO/Gs have not yet been established for most parameters. From a receiving water perspective, the parameters identified with a detection frequency of at least 20% (see Section 4.1) should be included in monitoring programs designed to mitigate these discharges. As a minimum, serious consideration should be given to the inclusion of compounds such as PAHs which are persistent, toxic to aquatic life and found at reasonably high frequencies of detection (ie. most PAHs were detected in excess of 50% of the WPCP effluent samples, using low level analytical techniques).

TABLE 4.1: SUMMARY OF FREQUENCY OF DETECTION

PARAMETER	UNITS	MDL	OUTFALLS - Winter		OUTFALLS - Fall		WFPs - (R.L. Clark)[3]		WPCPs	
			# SAMPLES	% DETECT	# SAMPLES	% DETECT	# SAMPLES	% DETECT	# SAMPLES	% DETECT
Conventionals										
Biochemical Oxygen Demand (5 day)	mg/L	1.00	138	95.7	124	97.6	9	100.0	12	100.0
Chemical Oxygen Demand	mg/L	2.00	138	98.6	127	95.3	9	100.0	34	100.0
Nitrates	mg/L	0.05	142	96.5	127	97.6	9	100.0	34	88.2
Total Kjeldahl Nitrogen	mg/L	0.05	142	99.3	127	100.0	9	100.0	34	100.0
Phenols	ug/L	0.2	131	98.5	125	97.6	9	55.6	30	100.0
Total Phosphorus	mg/L	0.02	142	92.3	126	91.3	9	100.0	34	100.0
Total Suspended Solids	mg/L	0.3	138	97.8	127	98.4	14	100.0	32	100.0
Bacteria										
Escherichia Coliform	#/dL	4	131	87.8	82	92.7	7	14.3	18	72.2
Fecal Coliform	#/dL	4	131	87.8	81	92.6	7	14.3	18	72.2
Metals										
Aluminum	mg/L	0.01	138	100.0	127	98.4	9	100.0	34	82.4
Barium	mg/L	0.02	138	95.7	127	100.0	9	77.8	34	100.0
Cadmium	mg/L	0.005	138	0.7	126	78.6	9	33.3	34	76.5
Chromium	mg/L	0.005	138	44.2	127	67.7	9	88.9	34	100.0
Copper	mg/L	0.002	138	92.0	127	94.5	9	88.9	34	100.0
Iron	mg/L	0.05	138	93.5	127	99.2	9	100.0	34	100.0
Lead	mg/L	0.01	138	23.2	127	85.0	9	66.7	34	88.2
Manganese	mg/L	0.005	138	94.9	127	100.0	9	100.0	34	100.0
Mercury	ug/L	0.01	137	14.6	123	22.8	9	77.8	32	78.1

TABLE 4.1: (cont'd) SUMMARY OF FREQUENCY OF DETECTION

PARAMETER	UNITS	MDL	OUTFALLS - Winter		OUTFALLS - Fall		WFPs - (R.L. Clark)^3		WPCPs	
			# SAMPLES	% DETECT	# SAMPLES	% DETECT	# SAMPLES	% DETECT	# SAMPLES	% DETECT
Nickel	mg/L	0.005	138	21.7	127	86.6	9	66.7	34	100.0
Silver	mg/L	0.01	138	13.8	126	68.3	9	44.4	34	67.6
Zinc	mg/L	0.005	137	86.1	127	95.3	9	77.8	34	100.0
Metalloids										
Arsenic	mg/L	0.001	138	20.3	127	1.6	9	88.9	34	8.8
Selenium	mg/L	0.001	138	9.4	127	3.1	9	0.0	34	14.7
Organochlorine Pesticides										
Total PCBs	ng/L	10.0	151	4.6	145	6.2	9	0.0	33	0.0
Alpha-BHC	ng/L	0.1	151	88.7	145	91.7	9	77.8	33	66.7
Gamma-BHC	ng/L	0.1	151	74.8	145	84.8	9	55.6	33	93.9
Alpha-Chlordane	ng/L	0.2			145	23.4	9	11.1	33	3.0
Gamma-Chlordane	ng/L	0.2			145	22.1	9	22.2	33	15.2
Dieldrin	ng/L	0.4	151	49.0	145	60.7	9	22.2	33	51.5
1,3,5 Trichlorobenzene	ng/L	0.2	151	7.9	145	16.6	9	44.4	33	48.5
1,2,4 Trichlorobenzene	ng/L	0.2	151	20.5	145	45.5	9	44.4	33	81.8
1,2,3 Trichlorobenzene	ng/L	0.1	151	11.9	145	20.0	9	55.5	33	69.7
1,2,3,4 Tetrachlorobenzene	ng/L	0.1	4	0.0	145	23.4	9	33.3	33	60.0
1,2,3,5 Tetrachlorobenzene	ng/L	0.1	151	27.8	145	51.7	9	11.1	33	57.6
Pentachlorobenzene	ng/L	0.1	151	7.3	145	18.6	9	66.6	33	48.5
Hexachlorobenzene	ng/L	0.1	151	7.3	145	24.8	9	44.4	33	36.4
Hexachlorobutadiene	ng/L	0.1	151	17.9	145	24.8	9	33.3	33	66.7
Hexachloroethane	ng/L	0.1	151	73.5	145	59.3	9	77.8	33	48.5

TABLE 4.1: (cont'd) SUMMARY OF FREQUENCY OF DETECTION

PARAMETER	UNITS	MDL	OUTFALLS - Winter		OUTFALLS - Fall		WFPs - (R.L. Clark)[3]		WPCPs	
			# SAMPLES	% DETECT	# SAMPLES	% DETECT	# SAMPLES	% DETECT	# SAMPLES	% DETECT
2,6,A Trichlorotoluene	ng/L	0.1	151	16.6	145	42.1	9	55.5	33	54.5
Chlorophenol Pesticides										
Pentachlorophenol	ug/L	1.0	131	22.1	115	15.7	22	0.0	11	45.5
Phenoxyacid Pesticides										
2,4 Dichlorophenoxyacetic	ng/L	100.0	131	13.7	118	13.6	9	11.1	11	54.5
2,4 Dichlorophenoxybutyric	ng/L	200.0	132	4.5	118	38.1	9	11.1	11	27.3
2,4 DP	ng/L	100.0	132	0.8	118	38.1	9	11.1	11	54.5
Volatile Organics[1]										
Bromochloromethane	ug/L	1.0	ND	ND	122	12.3	22	4.5	18	50.0
Chlorodibromomethane	ug/L	1.0	136	21.3	122	70.5	18	22.2	18	94.4
Chloroform	ug/L	1.0	137	38.7	122	91.8	18	27.8	18	100.0
Tetrachloroethylene	ug/L	1.0	136	2.9	121	43.0	18	5.6	18	94.4
1,1,1 Trichloroethane	ug/L	1.0	136	6.6	122	70.5	5	0.0	18	100.0
Trichloroethylene	ug/L	1.0	136	16.2	122	35.2	18	0.0	18	88.9
Resins and Fatty Acids										
Oleic Acid	ug/L	5.0	137	24.8	109	35.8	9	33.3	2	50.0
Palmitic Acid	ug/L	5.0	137	15.3	109	29.4	9	33.3	2	50.0
Stearic Acid	ug/L	5.0	137	11.7	109	33.0	9	11.1	2	50.0

TABLE 4.1: (cont'd) SUMMARY OF FREQUENCY OF DETECTION

PARAMETER	UNITS	MDL	OUTFALLS - Winter		OUTFALLS - Fall		WFPs - (R.L. Clark)[3]		WPCPs	
			# SAMPLES	% DETECT	# SAMPLES	% DETECT	# SAMPLES	% DETECT	# SAMPLES	% DETECT
Polynuclear Aromatic Hydrocarbons[2]										
Acenaphthene	ng/L	0.5	134	1.5	ND	ND	7	0.0	23	65.2
Acenaphthylene	ng/L	0.5	133	0.8	ND	ND	7	0.0	23	30.4
Anthracene	ng/L	0.5	134	0.7	82	7.3	7	0.0	23	91.3
Benzo (a) Pyrene	ng/L	0.5	133	0.0	39	7.7	7	0.0	23	4.3
Benzo (b) Fluoranthene	ng/L	0.5	108	0.0	85	4.7	7	0.0	23	30.4
Chrysene	ng/L	0.5	134	1.5	85	0.0	7	0.0	23	47.8
Fluoranthene	ng/L	0.5	134	1.5	85	2.4	7	0.0	23	87.0
Fluorene	ng/L	0.5	134	0.0	ND	ND	7	0.0	23	22.0
Naphthalene	ng/L	0.5	134	2.2	ND	ND	7	0.0	23	100.0
Phenanthrene	ng/L	0.5	134	3.7	85	2.4	7	0.0	23	91.3
Pyrene	ng/L	0.5	134	2.2	85	4.7	7	0.0	23	87.0

Note: 1 - MDL for volatile organics was typically 1.0 ug/L. Lower MDL used for sample collected in Fall.
2 - MDL for PAHs was typically between 0.2 and 1.0 ug/L. Lower MDL used for WPCPs only.
3 - Data for R. L. Clark plant presented for WFPs because backwash processing varied between plants.

TABLE 4.2(a): RANK OF DISCHARGES BY FLOW AND CONTAMINANT CONCENTRATIONS

DISCHARGE	Flow	Susp. Solids	Fecals		TP		Al		Cu		Fe		Zn		Phenols		Lindane		Dieldrin		1,2,4 TCB		TOTAL SCORE	NET RANK
Sewer Outfalls - Etobicoke																								
L103	8					*		*	8	*						*					8		7	9
L105				*		*		*	6	*		*				*					6		8	8
L202	7			*				*		*			1	*		*	8						8	8
L204		1		*		*	3	*		*	3	*	8	*	6	*							12	4
L308	1					*		*		*			2	*		*					5		8	8
L309	3			*	6	*	7	*		*		*	3	*	3	*							12	4
L401								*		*						*	6						4	11
L403				*	5	*		*		*				*	8	*					4		9	7
L405				*	7	*		*	7	*						*	7				2		9	7

Note:

SHADED BOXES:

- each represents an assigned score of 1
- "*" identify concentrations exceed PWQO/G
- # represent ranking of 10 highest values (eg. 1 is assigned to largest value)
- 2 columns of boxes used to identify the ranking and exceedances of PWQO/Gs for parameters which have PWQO/Gs; only 1 column is used to identify the ranking for those parameters which do not have PWQO/Gs.

TOTAL SCORE - total number of assigned scores (eg. total number of shaded boxes)

NET RANK - ranking of TOTAL SCORES (eg. 1 is assigned to highest TOTAL SCORE)

Susp. Solids	- suspended solids
Fecals	- Fecal Coliform bacteria
TP	- total phosphorus
1,2,4 TCB	- 1,2,4 trichlorobenzene

TABLE 4.2(b): RANK OF DISCHARGES BY FLOW AND CONTAMINANT CONCENTRATIONS

DISCHARGE	Flow	Susp. Solids	Fecals		TP		Al		Cu		Fe		Zn		Phenols		Lindane		Dieldrin		1,2,4 TCB		TOTAL SCORE	NET RANK
Sewer Outfalls - Toronto																								
W15	4		7	*	8	*		*	2	*						*							9	7
W6				*		*	9	*		*	7	*				*							8	8
W5	2		9	*	2	*		*		*		*			9	*	4						11	5
TH15	9				10	*		*		*		*	6	*		*							9	7
TH14	10		2	*	5	*		*		*		*		*	5	*	3		8		7		14	3
E12A		5		*		*		*		*	5	*	10	*		*			2		9		12	4
E12B	3			*		*		*		*	6	*	7	*	10	*			3				12	4
E11		4		*		*		*		*	8	*				*			1		10		10	6
E5	6	7				*	5	*	10	*	9	*				*			10				11	5
E1										*													1	12

Note:

SHADED BOXES:
- each represents an assigned score of 1
- "*" identify concentrations exceed PWQO/G
- # represent ranking of 10 highest values (eg. 1 is assigned to largest value)
- 2 columns of boxes used to identify the ranking and exceedances of PWQO/Gs for parameters which have PWQO/Gs; only 1 column is used to identify the ranking for those parameters which do not have PWQO/Gs.

TOTAL SCORE - total number of assigned scores (eg. total number of shaded boxes)

NET RANK - ranking of TOTAL SCORES (eg. 1 is assigned to highest TOTAL SCORE)

Susp. Solids	- suspended solids
Fecals	- Fecal Coliform bacteria
TP	- total phosphorus
1,2,4 TCB	- 1,2,4 trichlorobenzene

TABLE 4.2(c): RANK OF DISCHARGES BY FLOW AND CONTAMINANT CONCENTRATIONS

DISCHARGE	Flow	Susp. Solids	Fecals		TP		Al		Cu		Fe		Zn		Phenols		Lindane		Dieldrin		1,2,4 TCB		TOTAL SCORE	NET RANK
Sewer Outfalls - Scarborough																								
914			5	*		*		*															4	11
906		3	6	*	1	*	2	*	3	*	2	*		*	1	*	2		9				16	2
900A		2	3	*	4	*	1	*	4	*	1	*	4	*	4	*	5		7		3		18	1
901			8	*		*	6	*		*		*	9	*		*	1				1		12	4
903A			10	*	9	*		*		*		*				*			6				9	7
903B			1	*		*		*		*			5	*		*							8	8
929		9				*	4	*			4	*				*							7	9
925						*	10	*		*	10	*		*	7	*	10		4				11	5
919		10	4	*		*						*			2	*	9						8	8
301				*		*		*	9	*		*				*							7	9
913		8		*		*		*								*			3				6	10
927		6		*		*	8	*		*		*				*							8	8

Note:

SHADED BOXES:

- each represents an assigned score of 1
- "*" identify concentrations exceed PWQO/G
- # represent ranking of 10 highest values (eg. 1 is assigned to largest value)
- 2 columns of boxes used to identify the ranking and exceedances of PWQO/Gs for parameters which have PWQO/Gs; only 1 column is used to identify the ranking for those parameters which do not have PWQO/Gs.

TOTAL SCORE - total number of assigned scores (eg. total number of shaded boxes)

NET RANK - ranking of TOTAL SCORES (eg. 1 is assigned to highest TOTAL SCORE)

Susp. Solids	- suspended solids
Fecals	- Fecal Coliform bacteria
TP	- total phosphorus
1,2,4 TCB	- 1,2,4 trichlorobenzene

TABLE 4.2(d): RANK OF DISCHARGES BY FLOW AND CONTAMINANT CONCENTRATIONS

DISCHARGE	Flow	Susp. Solids	Fecals		TP		Al		Cu		Fe		Zn		Phenols		Lindane		Dieldrin		1,2,4 TCB		TOTAL SCORE	NET RANK
Water Filtration Plants																								
R.L. Clark WFP	1	2			2	•	2	•	2	•	2	•	1	•	2	•	1		1		1			
R.C. Harris WFP	2	1			1	•	1	•	1	•	1	•	2	•	1	•	2		2		2			
F.J. Horgan WFP	3	3			3	•	3	•	3	•	3	•	3		3	•	3		3		3			
Water Pollution Control Plants																								
Lakeview WPCP	3	4			3	•	2	•	2	•	4	•	3	•	1	•	4		3		3			
Humber WPCP	2	2			2	•	4		4	•	1	•	1	•	3	•	3		1		2			
Main WPCP	1	3		•	4	•	3	•	3	•	3	•	4	•	4	•	2	•	2		1			
Highland WPCP	4	1			1	•	1	•	1	•	2	•	2	•	2	•	1	•	4		4			

Note:

in boxes represent relative ranking of concentration values within each discharge group (eg. WFPs)
(1 is assigned to highest value)

"*" identify concentrations exceeding PWQO/Gs

Total Scores & Net Ranks are not presented for WFPs and WPCPs because each source exceeds PWQO/Gs for most of the parameters presented and the relative significance of these sources is based largely on flow and site specific conditions at the point of discharge.

Susp. Solids	- suspended solids
Fecals	- Fecal Coliform bacteria
TP	- total phosphorus
1,2,4 TCB	- 1,2,4 trichlorobenzene

TABLE 4.3: SUMMARY OF CONTAMINANT CONCENTRATIONS

PARAMETER	UNITS	PWQO	METRO BYLAW DSS[5]	MDL	OUTFALLS - Winter			OUTFALLS - Fall			WFPs - (R.L. Clark)[6]			WPCPs		
					Mean	Confidence Interval LL	UL	Mean	Confidence Interval LL	UL	Mean	Confidence Interval LL	UL	Mean	Confidence Interval LL	UL
Conventional Parameters																
Biochemical Oxygen Demand (5 day)	mg/L		15	1.00	5.06	3.7	6.9	4.64	3.27	6.59	15.6	7.4	32.8	11.7	10.7	12.8
Chemical Oxygen Demand	mg/L			2.00	18.2	0.8	406.5	29.1	23.3	36.3	54.2	36.4	80.6	317	223	451
Nitrates	mg/L			0.05	2.76	2.0	3.7	2.47	1.95	3.13	0.37	0.35	0.39	2.63	0.79	8.74
Total Kjeldahl Nitrogen	mg/L			0.05	0.645	0.0	15.2	0.68	0.58	0.79	4.03	2.59	6.26	24.1	21.4	27.1
Phenols	ug/L	1.0		0.2	2.798	2.1	3.7	4.42	3.52	5.55	4.45	3.06	6.46	10.3	9.27	11.4
Total Phosphorus	mg/L	0.02 G		0.02	0.18	0.1	0.2	0.12	0.092	0.16	0.67	0.48	0.93	0.58	0.52	0.64
Total Suspended Solids	mg/L		15	0.3	15.4	11.3	20.9	16.0	10.6	24.1	264.0	63.1	1100.0	25.0	20.3	30.8
Bacteria																
Escherichia Coliform	#/dL			4	605000	302500	1210000	15300	2860	81700	2 #					
Fecal Coliform[1]	#/dL	100	200	4	849000	420641	1713578	17400 ##	9690	31200	2 #				4	118
Metals[2]																
Aluminum	mg/L	0.075 G		0.01	0.186	0.01	4.76	0.15	0.13	0.17	25.0	21.3	29.3	0.19	0.087	0.41
Barium	mg/L			0.02	0.067	0.05	0.09	0.069	0.064	0.075	0.06	0.044	0.082	0.025	0.023	0.027
Cadmium	mg/L	0.00045*	0.001	0.005	0.002 #			0.003	0.003	0.004	0.002 #			0.003	0.002	0.004
Chromium	mg/L	0.1	0.2	0.005	0.01	0.01	0.01	0.007	0.006	0.008	0.038	0.023	0.062	0.009	0.008	0.011
Copper	mg/L	0.005*	0.01	0.002	0.053	0.04	0.08	0.019	0.015	0.024	0.027	0.013	0.054	0.016	0.013	0.02
Iron	mg/L	0.3		0.05	0.81	0.58	1.12	0.43	0.35	0.53	4.58	3.52	5.96	2.06	1.74	2.44
Lead	mg/L	0.005*	0.05	0.01	0.01	0.01	0.01	0.019	0.018	0.02	0.021	0.013	0.033	0.019	0.017	0.021

TABLE 4.3: (cont'd) SUMMARY OF CONTAMINANT CONCENTRATIONS

PARAMETER	UNITS	PWQO	METRO BYLAW DSS[5]	MDL	OUTFALLS - Winter			OUTFALLS - Fall			WFPs - (R.L. Clark)[6]			WPCPs		
					Mean	Confidence Interval		Mean	Confidence Interval		Mean	Confidence Interval		Mean	Confidence Interval	
						LL	UL		LL	UL		LL	UL		LL	UL
Manganese	mg/L			0.005	0.14	0.10	0.19	0.085	0.065	0.11	0.19	0.15	0.24	0.2	0.15	0.26
Mercury	ug/L	0.2	1.0	0.01	0.13 #			0.02 #			0.035	0.021	0.058	0.071	0.044	0.11
Nickel	mg/L	0.025	0.05	0.005	0.007	0.005	0.01	0.006	0.006	0.007	0.01	0.006	0.016	0.054	0.043	0.068
Silver	mg/L	0.0001		0.01	0.007 #			0.012	0.01	0.015	0.04	0.007	0.25	0.01	0.007	0.015
Zinc	mg/L	0.02[*]	0.05	0.005	0.052	0.04	0.07	0.047	0.035	0.064	0.058	0.019	0.18	0.063	0.054	0.074
Metalloids																
Arsenic	mg/L	0.1		0.001	0.003			0.001 #			0.025	0.01	0.061	0.001 #		
Selenium	mg/L	0.1		0.001	0.001 #			0.001 #			0.001 #			0.001 #		
Organochlorine Pesticides																
Total PCBs	ng/L	1.0		10.0	18.8 #			12 #			5 #			5 #		
Alpha-BHC	ng/L			0.1	0.89	0.68	1.17	0.85	0.73	0.98	3.6	0.45	28.9	0.95	0.43	2.11
Gamma-BHC (Lindane)	ng/L	10.0		0.1	0.44	0.33	0.58	0.44	0.38	0.51	8.37			11.2	6.53	15.2
Alpha-Chlordane	ng/L	60.0		0.2	0.28 #			0.15	0.13	0.17	0.14 #			0.10 #		
Gamma-Chlordane	ng/L	60.0		0.2	0.17 #			0.15	0.14	0.16	0.15 #			0.12 #		
Dieldrin	ng/L	1.0		0.4	0.28	0.22	0.36	0.29	0.26	0.32	0.15			0.23	0.21	0.26
1,3,5 Trichlorobenzene	ng/L	650.0		0.2	0.25 #			0.38 #			1.33			2.48	0.45	13.7
1,2,4 Trichlorobenzene	ng/L	500.0		0.2	2.77	1.59	4.82	2.05	0.95	4.41	1.99 #			23.1	18.2	43.4
1,2,3 Trichlorobenzene	ng/L	900.0		0.1	0.26 #						1.82			8.34	5.15	13.5
1,2,3,4 Tetrachlorobenzene	ng/L	100.0		0.1	0.05 #			0.34	0.13	0.91	1.66 #			8.05	3.82	17.0
1,2,3,5 Tetrachlorobenzene	ng/L	100.0		0.1	5.18	2.89	9.28	0.66	0.4	1.1	0.53 #			5.81	3.56	9.47
Pentachlorobenzene	ng/L	30.0		0.1	0.11 #			0.16 #			0.79			2.32	1.14	4.7

TABLE 4.3: (cont'd) SUMMARY OF CONTAMINANT CONCENTRATIONS

PARAMETER	UNITS	PWQO	METRO BYLAW DSS^5	MDL	OUTFALLS - Winter			OUTFALLS - Fall			WFPs - (R.L. Clark)^6			WPCPs		
					Mean	Confidence Interval LL	UL	Mean	Confidence Interval LL	UL	Mean	Confidence Interval LL	UL	Mean	Confidence Interval LL	UL
Hexachlorobenzene	ng/L	6.5		0.1	0.1 #			0.075	0.068	0.083	0.78 #			0.35	0.095	1.29
Hexachlorobutadiene	ng/L	8.0*		0.1	0.073 #			0.074	0.07	0.079	0.94			0.42	0.2	0.89
Hexachloroethane	ng/L	500.0*		0.1	0.24	0.18	0.31	0.31	0.26	0.37	0.76			0.59	0.16	2.13
2,6,A Trichlorotoluene	ng/L			0.1	0.11			0.28	0.17	0.45	0.67			0.62	0.19	2.04
Chlorophenol Pesticides																
Pentachlorophenol	ng/L	500.0		50.0	57.5	2.00	1651.2	39.3 #			25.0 #			51.7	49.8	53.7
Phenoxyacid Pesticides																
2,4 Dichlorophenoxyacetic	ng/L			100.0	97.6 #			43 #			88.9 #			112.0	62.0	202.0
2,4 Dichlorophenoxybutyric	ng/L			200.0	108.0 #			209.0	144.0	304.0	117.0 #			2980	542.0	16400
2,4 DP	ng/L			100.0	149.0 #			256.0	249.0	264.0	120.0 #			226.0	221.0	231.0
Volatile Organics^3																
Bromochloromethane	ug/L			0.027				0.019 #			0.030 #			0.052	0.032	0.086
Chlorodibromomethane	ug/L			0.012	0.88	0.06	13.93	1.33 ##	0.89	1.99	1.36			0.167	0.127	0.219
Chloroform	ug/L			0.014	1.54	0.13	17.78	2.70	1.29	5.64	4.89			3.31	2.20	4.98
Tetrachloroethylene	ug/L	50.0 G*		0.008	0.51 #			0.052	0.024	0.11	0.74 #			0.863	0.389	1.92
1,1,1 Trichloroethane	ug/L			0.013	0.73 #			0.174	0.096	0.316	0.1 #			0.794	0.347	1.820
Trichlorethylene	ug/L	2.0 G*		0.014	1.09 #			0.379			0.5 #			0.148	0.087	0.251

TABLE 4.3: (cont'd) SUMMARY OF CONTAMINANT CONCENTRATIONS

PARAMETER	UNITS	PWQO	METRO BYLAW DSS[5]	MDL	OUTFALLS - Winter			OUTFALLS - Fall			WFPs - (R.L. Clark)[6]			WPCPs		
					Mean	Confidence Interval		Mean	Confidence Interval		Mean	Confidence Interval		Mean	Confidence Interval	
						LL	UL		LL	UL		LL	UL		LL	UL
Resins and Fatty Acids																
Oleic Acid	ug/L			5.0	110.0	0.33	36248	19.2	9.14	40.3	23.6	1.12	495.0	24.7 #		
Palmitic Acid	ug/L			5.0	41.9 #			16.6	6.88	40.1	8.44	1.85	38.6	9.75 #		
Stearic Acid	ug/L			5.0	35.0 #			12.3	6.77	22.4	3.44			5.75 #		
Polynuclear Aromatic Hydrocarbons[4]																
Acenaphthene	ng/L			0.5										2.58	1.27	5.25
Acenaphthylene	ng/L			0.5										0.63	0.33	1.22
Anthracene	ng/L			0.5										0.3 #		
Benzo (a) Pyrene	ng/L			0.5										0.6 #		
Benzo (b) Fluoranthene	ng/L			0.5										1.19	0.28	5.15
Chrysene	ng/L			0.5										2.57	0.67	9.8
Fluoranthene	ng/L			0.5										7.18	3.76	13.7
Fluorene	ng/L			0.5										4.66	3.44	6.31
Naphthalene	ng/L			0.5										79.1	50.7	123.0
Phenanthrene	ng/L			0.5										8.42	5.29	13.4
Pyrene	ng/L			0.5										16.7	6.56	42.5

#	- Half Detection Limit Assigned to Detection Limit Values.
##	- Regression PDE used.
MDL	- Method Detection Limit
LL	- Lower Limit for 95% Confidence Interval
UL	- Upper Limit for 95% Confidence Interval
G	- Provincial Water Quality Guideline

Note: 1 - WPCP FC data presented as range in 1989 geometric means computed by Metro Works for 3 plants.
2 - Metals data are unfiltered totals.
3 - MDL for PAHs was typically between 0.2 and 1.0 ug/L. Lower MDL used for WPCPs only
4 - MDL for PAHs was typically between 0.2 and 1.0 ug/L. Lower MDL used for WPCPs only
5 - Metropolitan Toronto Sewer Use Bylaw No. 153-89 - Discharges to Storm Sewers
6 - Data for R.L. Clark plant presented for WFPs because backwash processing varied between plants
* - Proposed PWQO/G (MOE, 1991).

TABLE 4.4 EXCEEDANCES OF APPLICABLE PWQO/G OR METRO SEWER USE BYLAW TARGET CONCENTRATIONS BY DISCHARGE TYPE

PARAMETER	UNITS	PWQO	METRO[1]	OUTFALLS	WFPs[2]	WPCPs
CONVENTIONAL PARAMETERS						
Biochemical Oxygen Demand (5 day)	mg/L		15		▨	
Phenols	ug/L	1.0		▨	▨	▨
Total Phosphorus	mg/L	0.02 G		▨	▨	▨
Total Suspended Solids	mg/L		15	▨	▨	▨
BACTERIA						
Fecal Coliforms	#/dL	100	200	▨		
METALS						
Aluminum	mg/L	0.075 G		▨	▨	▨
Cadmium	mg/L	0.00045*	0.001	▨	▨	▨
Chromium	mg/L	0.1	0.2			
Copper	mg/L	0.005*	0.01	▨	▨	▨
Iron	mg/L	0.3		▨	▨	▨
Lead	mg/L	0.005*	0.05	▨	▨	▨
Mercury	ug/L	0.2	1.0			
Nickel	mg/L	0.025	0.05			▨
Silver	mg/L	0.0001		▨	▨	▨
Zinc	mg/L	0.02*	0.05	▨	▨	▨
METALLOIDS						
Arsenic	mg/L	0.1				
Selenium	mg/L	0.1				
ORGANOCHLORINE PESTICIDES						
Gamma-BHC (Lindane)	ng/L	10.0				▨
Alpha-Chlordane	ng/L	60.0				
Gamma-Chlordane	ng/L	60.0				
Dieldrin	ng/L	1.0				
1,3,5 Trichlorobenzene	ng/L	650.0				
1,2,4 Trichlorobenzene	ng/L	500.0				
1,2,3 Trichlorobenzene	ng/L	900.0				
1,2,3,4 Tetrachlorobenzene	ng/L	100.0				
1,2,3,5 Tetrachlorobenzene	ng/L	100.0				
Pentachlorobenzene	ng/L	30.0				
Hexachlorobenzene	ng/L	6.5				
Hexachlorobutadiene	ng/L	8.0*				
Hexachloroethane	ng/L	500.0*				
CHLOROPHENOL PESTICIDES						
Pentachlorophenol	ng/L	500.0				
VOLATILE ORGANICS						
Tetrachloroethylene	ug/L	50.0 G*				
Trichloroethylene	ug/L	2.0 G*				

Note:

Shaded Boxes identify exceedances of PWQO/Gs (if Bylaw targets are available) or Bylaw targets (if PWQO/Gs are not available).

1 - Metropolitan Toronto Sewer Use Bylaw No. 153-89 - Discharges to Storm Sewers.

2 - Data for R.L. Clark Plant presented for WFPs because backwash processing varied between plants.

G - Provincial Water Quality Guideline.

* - Proposed PWQO/G (MOE, 1991).

5.0 CONTAMINANT LOADINGS

5.1 Comparison of Contaminant Loadings Between Types of Discharges

Mean contaminant loadings for each type of discharge are summarized in Table 5.1 for those parameters which were detected in at least 20% of samples collected from either the sewer outfalls or WPCP effluents.

Mean contaminant mass loadings for these types of discharges are compared in Figures 5.1 to 5.3 for 18 parameters considered. Figure 5.1 presents mean contaminant loadings for six conventional water quality parameters: suspended solids, fecal coliform bacteria, total phosphorus, total kjeldahl nitrogen, biochemical oxygen demand and phenolics. Figure 5.2 presents mean estimates for six heavy metals: aluminum, copper, iron, manganese, nickel and zinc. Figure 5.3 presents mean estimates for six organic contaminants: dieldrin, lindane, 1,2,4 trichlorobenzene, 1,2,3,5 tetrachlorobenzene, pentachlorobenzene and hexachlorobenzene.

The 95% confidence interval is presented with the mean loadings for the outfalls, WFPs and WPCPs in Figures 5.1 to 5.3. The confidence interval provides a measure of the degree of variability associated with the mean loading estimate. The confidence interval is influenced by the variability in both the flow and concentration data sets. The presentation by class of discharge includes the variability associated over space (ie. between sources), time and measurement (ie. chemical analysis and flow measurement).

For the parameters presented in Figures 5.1 to 5.3, the WPCPs are generally the most significant source of contaminant discharges to the waterfront. In comparison to the outfalls and WFPs, the WPCP contaminant contribution is typically one to two orders of magnitude larger for 15 of the 18 parameters.

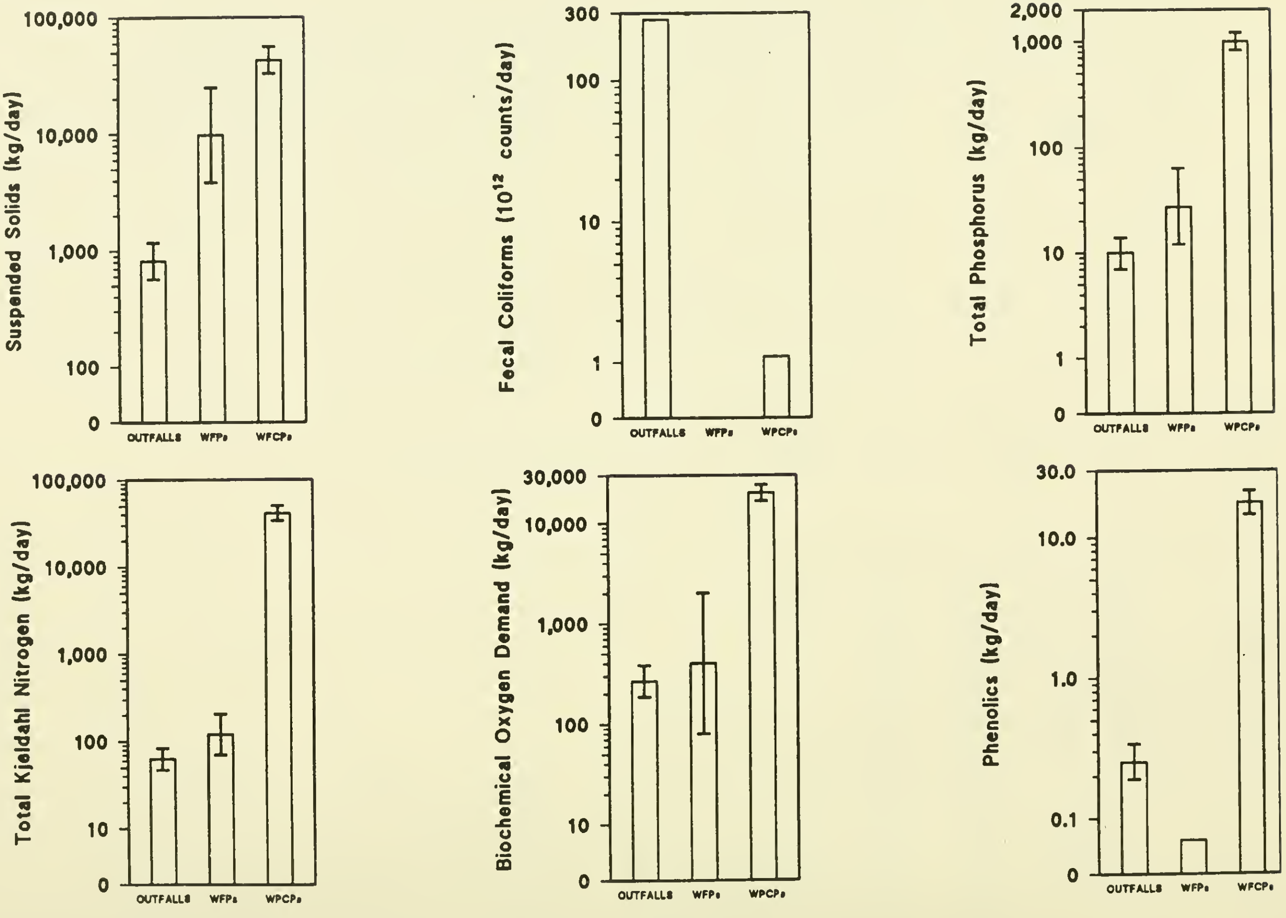


Figure 5.1 Mean contaminant loadings with the 95% confidence interval for general water quality parameters.

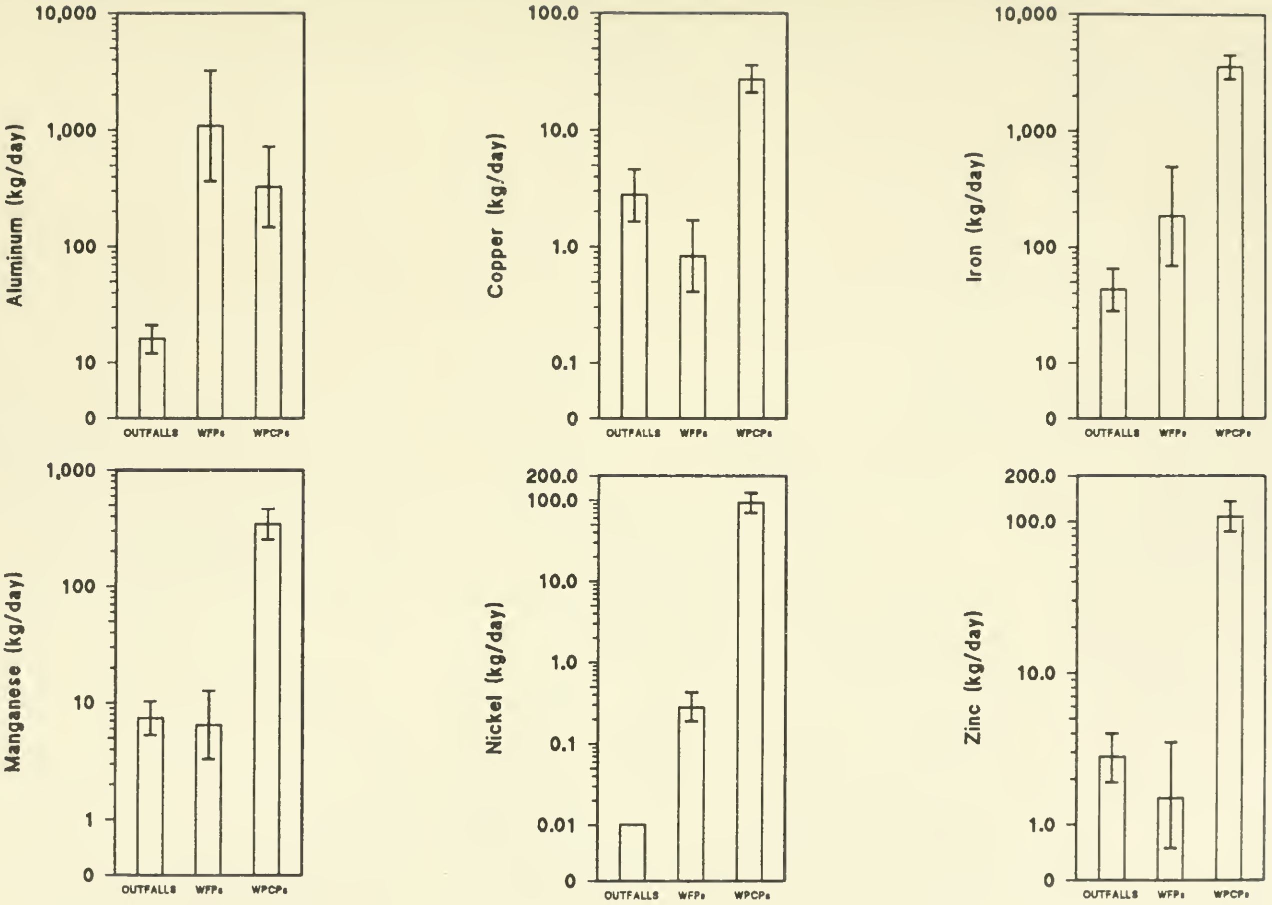


Figure 5.2 Mean contaminant loadings with the 95% confidence interval for heavy metals.

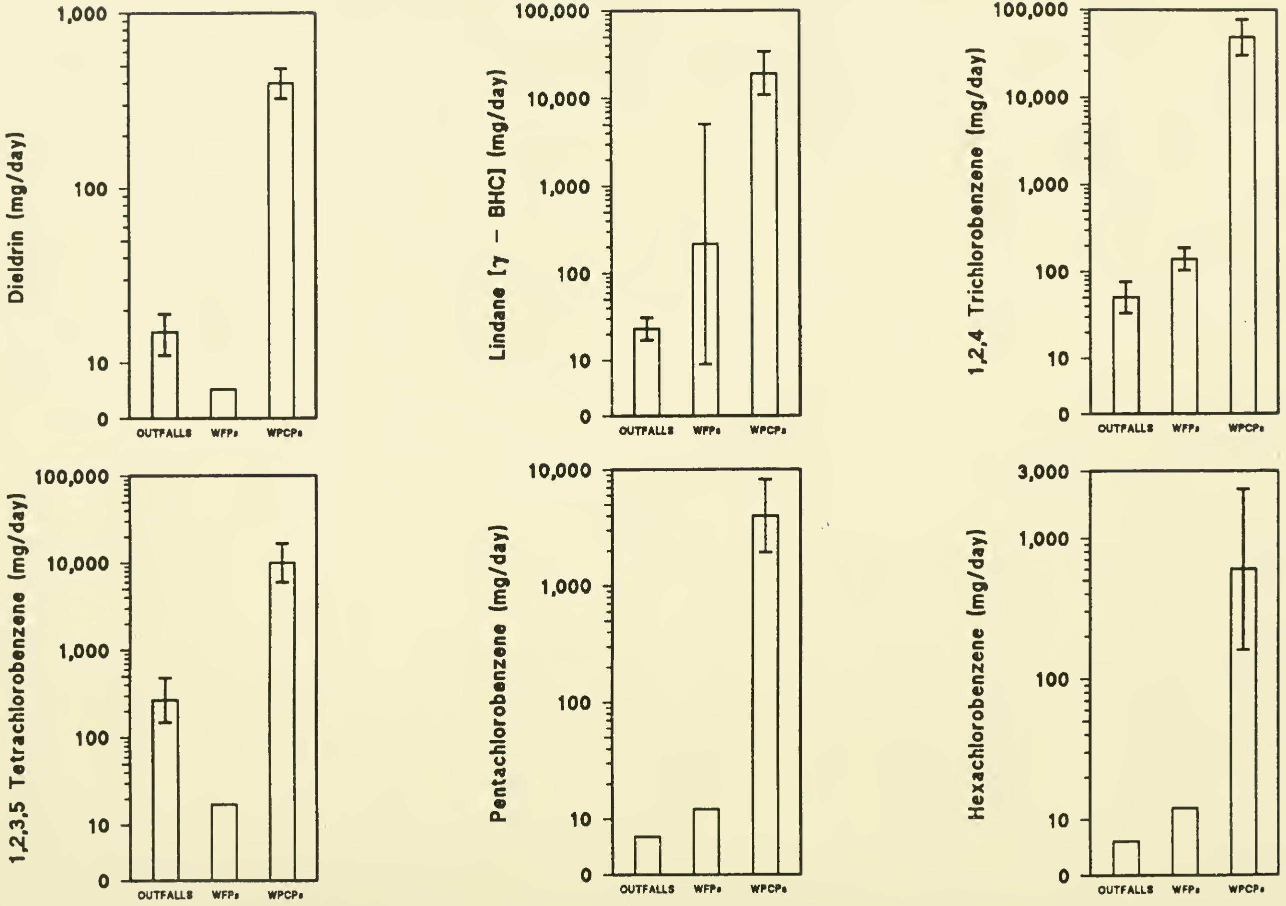


Figure 5.3 Mean contaminant loadings with the 95% confidence interval for organic parameters.

WFPs are the largest source of aluminum. Aluminum loadings are expected to be significant since aluminum is used as a coagulant to remove suspended solids. In comparison to WPCPs, WFPs are significant sources (within an order of magnitude) of total suspended solids, barium, chromium, iron, mercury and volatile organic compounds such as chlorodibromomethane, chloroform and trichloroethylene (see Table 5.1). WFP loadings are, however, over-estimates because of the sampling procedure used.

It should be noted that aside from a few contaminants such as aluminum and the volatile organic compounds, the WFPs do not generate a significant net loading to Lake Ontario because most of the contaminants measured in the backwash water are drawn from the Lake with the raw water. While most of the particulate material removed and subsequently discharged through the backwash water was originally drawn from the Lake, the discharge of concentrated material may impact local areas near the point of discharge.

Waterfront outfalls are the largest source of dry weather fecal coliform loadings, exceeding WPCP loadings by two orders of magnitude. Otherwise, contaminant loadings from all waterfront outfall discharges are lower than WPCP discharges for all parameters. Outfall loadings for parameters such as aluminum, barium, copper, dieldrin, chlorodibromomethane, trichloroethylene, oleic acid, palmitic acid and stearic acid are within an order of magnitude of WPCP loadings.

With the exception of fecal coliforms, contaminant loadings from waterfront outfalls and WFP discharges are generally within the same order of magnitude. In comparison to WFP discharges, loadings for waterfront outfalls are higher for fecal coliform bacteria, phenolics, copper, dieldrin, and 1,2,3,5 tetrachlorobenzene. Loadings from the outfalls and WFPs are similar for biochemical oxygen demand, manganese, zinc, lindane and hexachlorobenzene. WFP loadings are much larger for suspended solids, total phosphorus, total kjeldahl nitrogen, aluminum, iron, nickel and 1,2,4 trichlorobenzene.

While this analysis provides an evaluation of contaminant loadings from the sources monitored, a comparison between all sources discharging to the waterfront requires the completion of separate studies evaluating wet weather loadings from waterfront sewer outfalls, and loadings from the tributaries discharging to the waterfront.

TABLE 5.1: SUMMARY OF CONTAMINANT LOADINGS

PARAMETER	UNITS	OUTFALLS			WFPs			WPCPs			TOTAL
		Mean	Confidence Interval		Mean	Confidence Interval		Mean	Confidence Interval		
			LL	UL		LL	UL		LL	UL	
Flow	MLD	32			32			1660			1730
Conventional Parameters											
Biochemical Oxygen Demand (5 day)	kg/d	268	187	384	402	80	2010	20100	16600	24200	20770
Nitrates	kg/d	146	104	206	11	9	15	4520	1340	15200	4680
Total Kjeldahl Nitrogen	kg/d	63	47	84	120	70	207	41200	33700	50400	41400
Phenol	kg/d	0.25	0.19	0.34	0.03 #			17.7	14.5	21.5	18
Total Phosphorus	kg/d	10	7	14	27	12	63	996	820	1210	1030
Total Suspended Solids	kg/d	815	567	1170	9810	3840	25000	42800	32800	56000	53425
Bacteria											
Fecal Coliform	gct/d	270 #			0.0 #			1.1 #			271
Metals											
Aluminum	kg/d	16	12	21	1090	366	3210	326	147	720	1430
Barium	kg/d	3.5	2.8	4.4	1.8	1.3	2.4	42.8	35.7	51.2	48
Cadmium	kg/d	<0.01 #			0.02 #			5.0	3.7	6.6	5
Chromium	kg/d	0.53	0.36	0.79	1.08	0.54	2.17	16.3	13.2	20.2	17.9
Copper	kg/d	2.81	1.64	4.62	0.83	0.41	1.68	27.4	21.0	36.0	31
Iron	kg/d	43	28	65	185	69	492	3540	2790	4480	3770
Lead	kg/d	0.52	0.34	0.78	0.53	0.39	0.71	32.6	26.8	39.6	34
Manganese	kg/d	7.4	5.3	10.3	6.5	3.3	12.7	343	253	464	357
Mercury	g/d	0.02 #			1.05	0.52	2.13	1.22	73.2	203.0	123

TABLE 5.1: (cont'd) SUMMARY OF CONTAMINANT LOADINGS

PARAMETER	UNITS	OUTFALLS			WFPs			WPCPs			TOTAL
		Mean	Confidence Interval		Mean	Confidence Interval		Mean	Confidence Interval		
			LL	UL		LL	UL		LL	UL	
Nickel	kg/d	0.01 #			0.28	0.19	0.43	92.8	70.0	123.0	93
Zinc	kg/d	2.8	1.9	4.0	1.5	0.6	3.5	108	86	136	112
Metalloids											
Arsenic	kg/d	0.003 #			1.3	0.29	5.82	0.27 #			1.6
Selenium	kg/d	0.001 #			0.005 #			0.47 #			0.5
Organochlorine Pesticides											
Total PCBs	mg/d	24 #			231 #			2150 #			2405
Alpha-BHC	mg/d	47	36	62	101	40	257	1630	724	3680	1778
Gamma-BHC	mg/d	23	17	31	215	9	5040	19200	10900	33800	19440
Dieldrin	mg/d	15	11	19	7 #			395	324	480	417
1,3,5 Trichlorobenzene	mg/d	13 #			187 *	134	261	4240	764	23600	4440
1,2,4 Trichlorobenzene	mg/d	50 *	33	76	139 *	103	187	48400 *	30400	77200	48590
1,2,3 Trichlorobenzene	mg/d	14 #			257	39	1690	14300 *	8600	23800	14570
1,2,3,4 Tetrachlorobenzene	mg/d	3 #			20 #			13800 *	6440	29600	13820
1,2,3,5 Tetrachlorobenzene	mg/d	268	149	482	17 #			9960 *	5960	16700	10200
Pentachlorobenzene	mg/d	6 #			12 #			3980 *	1930	8240	4000
Hexachlorobenzene	mg/d	5 #			12 #			600	160	2240	616
Hexachlorobutadiene	mg/d	4 #			0.5 #			720	334	1550	724
Hexachloroethane	mg/d	12	9	16	33 #			1010	278	3690	1055
2,6,A Trichlorotoluene	mg/d	6 #			29			1060	320	3540	1090

TABLE 5.1: (cont'd) SUMMARY OF CONTAMINANT LOADINGS

PARAMETER	UNITS	OUTFALLS			WFPs			WPCPs			TOTAL
		Mean	Confidence Interval		Mean	Confidence Interval		Mean	Confidence Interval		
			LL	UL		LL	UL		LL	UL	
Chlorophenol Pesticides											
Pentachlorophenol	g/d	0.04 #			16 #			89	75	105	105
Phenoxyacid Pesticides											
2,4 Dichlorophenoxyacetic	g/d	5.1 #			2.5 #			192	104	355	200
2,4 Dichlorophenoxybutyric	g/d	5.7 #			1.7 #			5120	924	2840	5127
2,4 DP	g/d	7.8 #			4.1 #			388	329	460	400
Volatile Organics											
Bromochloromethane	g/d	0.02 #			0.7 #			90	53	152	90
Chlorodibromomethane	g/d	50 #			197			286	209	393	534
Chloroform	g/d	77 #			461			5680	3660	8840	6218
Tetrachloroethylene	g/d	27 #			0.1 #			1480	656	3340	1507
1,1,1 Trichloroethane	g/d	38 #			3.1			1360	588	3170	1401
Trichloroethylene	g/d	57 #			16			254	146	440	327
Resins and Fatty Acids											
Oleic Acid	g/d	5774	3365	9919	380 #			10600 #			16800
Palmitic Acid	g/d	697	277	1760	210 #			4180 #			5090
Stearic Acid	g/d	2196 #			91 #			2470 #			4750

TABLE 5.1: (cont'd) SUMMARY OF CONTAMINANT LOADINGS

PARAMETER	UNITS	OUTFALLS			WFPs			WPCPs			TOTAL
		Mean	Confidence Interval		Mean	Confidence Interval		Mean	Confidence Interval		
			LL	UL		LL	UL		LL	UL	
Polynuclear Aromatic Hydrocarbons[1]											
Acenaphthene	g/d							4.3	2.1	9.2	
Acenaphthylene	g/d							1.0	0.5	2.1	
Anthracene	g/d							0.5 #			
Benzo (a) Pyrene	g/d							1.0 #			
Benzo (b) Fluoranthene	g/d							2.0	0.5	8.9	
Chrysene	g/d							4.3	1.1	17.0	
Fluoranthene	g/d							11.9	6.3	24.0	
Fluorene	g/d							7.7	5.7	11.3	
Naphthalene	g/d							131.3	84.4	21.8	
Phenanthrene	g/d							14.0	8.8	23.6	
Pyrene	g/d							27.7	11.1	74.0	

MLD - Million Litres per Day
gct - gega (10^{12}) counts/day
* - Regression PDE Used
# - Half Detection Limit Assigned to Detection Limit values
LL - Lower Limit for 95% confidence interval
UL - Upper Limit for 95% confidence interval

Note: 1 - Loadings for PAHs were not computed for Outfalls and WFPs because their MDL was 3 orders of magnitude higher than WPCP data set.

6.0 CONCLUDING STATEMENTS

The following statements concerning the parameters contained in the data base are drawn from this study:

1. This study has developed the first data base characterizing the concentration of organochlorine pesticides, chlorobenzenes, PCBs, volatile organic compounds and polynuclear aromatic hydrocarbons in direct dry weather discharges from storm sewers and combined sewer overflow outfalls, water pollution control plant effluents and backwash water from water filtration plants along the Metropolitan Toronto Waterfront.

2. A comprehensive database for a wide range of contaminants including nutrients, bacteria, heavy metals and trace level organic compounds has been compiled.

3. Low level analytical techniques were used to measure concentrations of priority organic pollutants. This entailed using solvent extraction procedures on larger volume samples (16 litres) than normally used (1 litre). This has resulted in improving the analytical detection limit by a factor of 10 over traditional techniques.

4. Many more priority pollutants were identified in the WPCP discharges than previous studies due to enhanced detection limits.

5. A list of parameters with relatively high detection frequencies has been compiled. This list should be considered in the selection of target compounds for future monitoring programs directed at dry weather sewer outfall discharges and WPCP effluents. Similarly, parameters where discharge concentrations are generally in exceedance of applicable receiving water criteria have been identified for consideration in future regulatory monitoring programs.

6. Priority pollutants have been identified in a significant number of samples collected from dry weather sewer outfall discharges.

7. The outfall flow rates measured during the winter period were slightly larger than those measured in the fall. The main difference in these flow rates occur in the City of Scarborough, where the winter flow rates were approximately 4 times larger than those measured during the fall and more outfalls were dry during the fall.

The following statements are made concerning the relative concentrations measured in outfalls, WFPs and WPCPs:

1. On average, dry weather outfall discharges exceeded PWQO/Gs for many water quality parameters including fecal coliform bacteria, total phosphorus, phenols, aluminum, copper, iron and zinc.

2. WFP backwash concentrations exceeded PWQO/Gs for total phosphorus, aluminum, copper, iron and phenols. WFPs concentrations are in compliance with PWQOs for organochlorine pesticides and bacteria.

3. WPCP effluent concentrations were found to be higher than those measured in outfalls and WFPs. WPCP effluent is in exceedance of most PWQO/Gs for most parameters presented. With the exception of lindane, WPCP concentrations are however lower than PWQOs for organochlorine pesticides.

4. For many parameters, concentrations measured for individual outfall discharges are larger than those measured for WPCPs and WFPs.

5. Thirty-one of 103 sewer outfalls located along the waterfront have been identified as discharging significant flow. With the exception of one outfall, each outfall discharge

is in exceedance of PWQO/Gs for several parameters. A ranking of outfall discharges with respect to significance of flow and contaminant concentrations has been included for the prioritization of outfalls requiring remediation.

6. Comparing concentrations between WFPs, the F.J. Horgan Plant produces much lower contaminant concentrations, generally by an order of magnitude over the other two plants. This is attributed to the clarifier used at the F.J. Horgan Plant which separates the solids from the backwash water.

The following statements are made concerning the relative importance of the three types of sources for dry weather loadings to the waterfront:

1. By comparing the contaminant loading contribution from the three types of sources, the WPCPs are generally the most significant source. In comparison to dry weather sewer outfall discharges the WPCP contaminant loadings are typically one to two orders of magnitude larger.

2. WFPs are the largest source of aluminum. In comparison to WPCPs, WFPs are significant sources (within an order of magnitude) of total suspended solids, barium, chromium, iron, mercury and volatile organic compounds such as chlorodibromomethane, chloroform and trichloroethylene.

3. Contaminant loadings from all waterfront outfall discharges are low in comparison to WPCPs, except for fecal coliforms. Loadings for fecal coliform bacteria exceed WPCP loadings by two orders of magnitude. In comparison to WPCPs, dry weather loadings from outfalls are significant sources (within an order of magnitude) of aluminum, barium, copper, dieldrin, chlorodibromomethane, trichloroethylene, oleic acid, palmitic acid and stearic acid.

4. A thorough comparison between all discharges along the waterfront requires the completion of other studies evaluating wet weather loadings from waterfront sewer outfalls, and loadings from the tributaries discharging to the waterfront.

7.0 REFERENCES

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